Suspended Sediment Monitoring Project

San Simon Watershed

Southeast Arizona

1983 to 1995

97-09614

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Executive Summary

In the 1930's, watershed restoration work in the San Simon Valley began with projects by the Civilian Conservation Corps. Restoration continued into the 1940's and 1950's with the construction of detention dams on the main stem of the river and it's major tributaries, first by the Soils Conservation Service and then by the Bureau of Land Management. Downstream irrigators demanded that the government cease construction of dams that could interfere with their supply of water. The Secretary of the Interior halted further dam construction with the issuance of a Stop Work Order during the 1960's and 1970's. Dam construction re-commenced in 1930 and continued through 1983, until a total of 19 detention dams were completed.

In the 1980's and 1990's, the implementation of range management projects and practices by BLM and at least one rancher were undertaken in an attempt to restore the vigor of the land and reduce soil erosion.

In late-1982/early-1983, the monitoring of stormflow and suspended sediment from the San Simon watershed began with the installation of specialized measuring equipment at the Barrier Detention Dam. At later dates, additional monitoring equipment was installed at Bailey Well, Fan Dam and Yellowhammer Well.

Three recording raingages were operational within the watershed providing data for other District programs. This precipitation data would also be used in this monitoring project. Later, additional gages were added while two were lost to vandalism. Numerous non-recording raingages were also installed across the northern third of the watershed to provide additional precipitation data for end-of-fiscal year reports to management.

The parameters examined were: precipitation occurring within and along the periphery of the watershed, stormflow measured at three sites on the main channel, movement of suspended sediment through and out of the river system, and measurement of free salt ions in solution (Electrical Conductivity).

The monitoring program examined these parameters within the watershed over a 13-year period. The conclusion is that the stream channel, and possibly some of the watershed, is slowly recovering, despite over 100 years of abuse. The construction of erosion control structures and the implementation of a number of range management practices have apparently contributed to this healing process.

The decline in stormflow and sediment yield, and the reduction in the number of flow days during this study may be viewed as an indication that a significant number of projects have been

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installed or initiated within the watershed to reduce and control erosion. Among these projects were the construction of detention dams, the implementation of range management practices (including reduction of cattle numbers, fencing of riparian areas, construction of numerous rock masonry dams by one rancher, installation of dependable waters to disperse livestock and wildlife), concrete drive-through (river fords), grass seedings, and Civilian Conservation Corp erosion control structures. Although there is still a long way to go before the San Simon watershed nears full recovery, the process of restoration appears at least to be in an upward trend.

San Simon River Suspended Sediment Monitoring Project

End-of-Project Report

Objectives of the Study

This monitoring project was initiated to determine whether existing erosion control structures and projects, and the implementation of past and current management practices across the watershed were effective in actually reducing the quantities of sediment leaving the watershed, and to discern whether there was an upward trend in watershed condition. Later, additional monitoring was undertaken to determine whether salinity was a problem.

History of the San Simon Watershed

Information taken from the diaries of early pioneers of the late 1800's, revealed that the San Simon watershed was once capable of maintaining perennial flow. More than one person described the valley as having grasses as high as the stirrups of their saddle or the belly of the animals, with water flowing gently through the swales. It was reported that early settlers were able to fish in the stream. To the Spanish-speaking people during the mid-1800's, the perennial stream was known by two names: the Rio San Domingo and the Rio De Sauz, the latter name likely because willow trees grew along the streambanks and several cienegas existed in the vicinity of what is now the Arizona-New Mexico state border. (Barnes 1936, Barnes 1960)

The construction of a ditch to drain excess waters away from fields in the San Simon valley above the confluence with the Gila River, the development of a freight wagon trail up the valley to the towns of San Simon and Bowie, and the introduction of 50,000 to 100,000 head of cattle (estimates vary) into the watershed, coupled with very severe droughts during 1903 through 1905 and 1914 through 1915, followed by heavy rains at the end of each drought wreaked erosional havoc upon the watershed.

Severe head cutting led to the formation of gullies that quickly moved up the valley with each major flood. By the 1940's, the San Simon watershed was recognized as one of the most degradated watersheds in the United States. (Peterson 1960, Ryan 1963, Weiler 1969) The cutting and deepening of the stream channel and it's major tributaries resulted in the lowering of the water table which caused perennial vegetation to die off and led to eventual loss of soil cover. Sheet erosion occurred throughout the area and the watershed was invaded by many undesirable plant species.

Today the San Simon River is an ephemeral stream; The main channel and all tributaries flow only during and after storm events. Unless a subsequent storm occurs, the runoff rarely continues for

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more than two days. Flow records reveal that a series of two or three subsequent storms can maintain eight to twelve days of stormflow.

History of the San Simon Restoration Projects

Since the 1930's, numerous restoration projects have been initiated to control extensive soil erosion occurring across the watershed. During the 1930's, the Civilian Conservation Corps constructed numerous small rock barriers to control sheet erosion, and small diversion dams, dikes, and gully plugs throughout the watershed. In the 1940's, the Soil Conservation Service constructed the first three major detention dams in the area, the Lower and Upper Cienega Detention Dams on the main channel and Goat Well Detention Dam on a major tributary. The Bureau of Land Management designed and built Fan Detention Dam on the main channel in 1953. Since then, an additional 15 detention dams have been constructed, including Barrier Dam in 1980, Slick Rock in 1981 and South Well and Creosote Detention Dams in 1982-83.

During 1956-58, the Geological Survey measured sediment deposition at Creighton and Gold Gulch Detention Dams. In July and August of 1957, they also measured suspended sediment load at their streamgaging station near Solomon. They computed an estimated 666 acre-feet of sediment was lost from a mean yearly discharge of 10,419 acre-feet of stormflow, (Peterson 1960, Ryan 1963) which computes to a sediment load ratio of 0.064 acre-feet of sediment per acre-foot of stormflow. The highest ratio of sediment load to stormflow (0.040) during this monitoring program occurred in Calendar Year 1985. This ratio will be discussed further later in this document.

History of Range Management Practices

Bureau of Land Management

Over the past 15 years, improved livestock management practices were initiated on public lands in the San Simon watershed in order to restore overall watershed conditions by increasing ground cover. Subsequent vegetative monitoring transects have indicated an upward trend in ground cover on many of the allotments. The BLM manages 49% of the acreage within the watershed, comprising the majority of the land lying north of Interstate 10 and in the Dos Cabezas Mountains, which presently contains 23 allotments. Beginning in 1980, livestock reductions averaging 23% were implemented on these allotments reducing permitted grazing from 3353 animal units to 2569 animal units. The majority of the allotments are currently under a rotational grazing system, while portions of the San Simon channel are fenced and generally excluded from grazing.

Ranchers

One particular rancher is committed to protecting and improving the lands within his allotment, and has constructed a series of multiple rock-masonry dams on federal, state and private lands. In each set of these dams, the upstream dams capture and hold the sediment, allowing water to filter through to lower dams. Vegetation eventually grows on and adjacent to each of the filtering dams and along the edges of the wetted channel bottom. This improves the quality of the surface water, while reducing soil erosion from the drainage. Most of the lower dams retain water for ten to twelve months.

History of the Suspended Sediment Project

Barrier Dam

Following the construction of Barrier Dam in 1980, the Safford District's sediment monitoring project was initiated in order to measure the quantities of surface water and suspended sediment (soil particles in solution) leaving the watershed. Equipment was installed at the Barrier Detention Dam in November of 1982, beginning with a Leupold & Stevens A-35 water level recorder. The housing for the recorder was mounted on a segment of inverted culvert which served as the stilling well. (See the Appendix for a full description of the station.)

The second piece of equipment was a Manning Portable Discrete Sampler, Model S-4050-A. The instrument was housed in a steel-plated shelter erected on the dam embankment, east of and adjacent to the spillway, but separate from the water level recorder. The battery-powered instrument collected sediment-laden water samples when activated during stormflow. (See the Appendix for description of equipment operation.)

The monitoring unit was put into service in December of 1982, but the Sampler failed to operate properly and was returned to the factory for adjustments: the water sample had to be lifted a height of 15 feet. By mid-March of 1983, the sampler was returned to operation.

Bailey Well/Fan Dam

To determine whether suspended-sediment differences existed along segments of the stream and within the watershed, additional data collection stations were established in mid-September of 1983. A three-bottle set of single-stage sediment samplers was installed at Bailey Well, with one bottle each at Fan Dam's two outlets, the Drop Inlet and the Chute. (See the Appendix for an explanation of the single-stage sediment sampler.)

In February of 1984, a fourth bottle was added to the Bailey Well system and a second bottle was added to the Fan Dam Drop Inlet. Since the weep tubes at the Chute had ceased to function after the

1983 flood and water no longer flowed through the Chute, the equipment was eventually removed.

Precipitation Data

Prior to initiation of the suspended sediment monitoring program, the District had began to collect data in the watershed with the installation of several recording raingages (See Appendix for description of raingages). Originally, the gages had not been installed for the project, but were in place to provide baseline data for the District's range and wildlife programs, since the nearest precipitation data stations were maintained for the Weather Bureau and were located at distant populated areas. To ensure usable data, the raingages were installed at field sites selected by the personnel who would use the data, a practice that was continued when additional recording raingages were installed later in the project. No data was collected from the southern half of the watershed because the distance from the office was too great and the amount of time that would have been required for travel and equipment maintenance was prohibitive.

The Tanque raingage has operated continuously since mid-1980. In late 1982, the Howard Well raingage was installed. By mid-1983, the Ash Peak raingage began recording data, and the Van Gausig gage went into operation in early 1989.

The Elma Mine raingage, located in the Dos Cabezas Mountains, was also operational by mid-1982, but the data will not be used because the high elevation location (6420 feet) skews the averages. Data collection ceased in mid-1987 when the instrument was destroyed by vandals.

The Howard Well raingage was also vandalized and destroyed in late-1989. Due to irregular servicing of the instrument and the subsequent loss of data, the Ash Peak raingage was removed from its site in mid-1993.

Non-recording Raingages

Numerous non-recording raingages were installed at various times across the lower third of the watershed, from Barrier Dam to Yellowhammer Well, seven miles northeast of the town of San Simon. They were to be used to supplement data collected from the recording raingages although many of them never stayed in place for very long due to vandalism or theft. The remaining gages continued to function despite mass suicidal frenzies by winged ants, bees, or flies and the occasional vandalism or theft. When a gage was disturbed, that year's data was lost. Because the gages were serviced to accommodate the end-of-fiscal year reports, the data is unusable for this publication.

Channel Transects and Photo Points

After construction of Fan Detention Dam was completed in 1953, permanent markers were established, transect lines were surveyed across the reservoir and the upstream channel up to the First National Well area, and photo points were established. During 1990, many of the transect lines were found and re-surveyed.

In July 1983, five cross-section transects were established and surveyed on the channel above Barrier Dam. Usually, the marker for each transect also served as the photo point. These sites were re-surveyed in mid-1989 and again in mid-1995

District Management expressed interest in whether the stream channel may be aggrading in the vicinity of Bailey Well and Yellowhammer Well. This prompted the establishment of three additional cross-channel transects in late 1989. The first transect was surveyed in at Bailey Well, with the other two located in the vicinity of Yellowhammer Well, The Yellowhammer North transect was located approximately one-half mile north of the river crossing to the well. The Yellowhammer South transect was located one-fifth mile south. In early 1992, Bailey Well and Yellowhammer South were re-surveyed. All sites were re-surveyed in mid-1995.

Additional Streamgaging Stations

Lack of flow data at Fan Dam and further upstream created a need for several streamgaging stations to be installed. In mid-1990, one station was placed within and attached to the Drop Inlet at Fan Dam, while a second station was set into the earthen streambank and anchored into the streambed one-fifth of a mile above the Yellowhammer Well road. The aerial distance between the two stations is 8.5 miles. Each station possesses a stilling well with housing mounted above it, and a Leupold & Stevens A-35 or A-71 Water Level Recorder. The Yellowhammer station was outfitted with a pair of intake tubes leading from the stilling well out into the channel.

Data Collection and End-of-Year Reports

The parameters monitored over the duration of the project included precipitation, stormflows (quantities and duration), suspended sediment, Electrical Conductivity (measurement of free salt ions in solution) and channel aggradation. After the data had been collected, analyzed, tabulated and compiled each year, it was included in an end-of-year report distributed to in-house Managers and other interested parties

Each report contained not only an analysis of the data, but also updates on equipment failures, new installations, and other pertinent information. Excluding the first report, the time frame was from September through August, which allowed enough time to analyze late data and to complete the report by the end of each fiscal year.

Data Collection, Analysis, Tabulation, Computation and Compilation

Raingages, Recording

Table 1 shows the precipitation data from the Weather Bureau and Bureau of Land Management (BLM) raingage stations used during the study. The data is tabulated by calendar year for all stations. Except for one station, the data was collected basically from the periphery of the main project area.

Figure 1 (Parts 1 and 2) displays the data from Table 1. Each year's data shows the range of precipitation for the stations used, the last number indicating the average of that year's data. This number was not derived from the usual averaging of the yearly total for each station, but rather by summing the monthly averages. This allowed the inclusion of monthly data that is not normally used for lack of twelve full months of data. In most cases, the difference between the two sums was minimal.

Table 2 displays the average of the Weather Bureau and BLM stations by calendar year. Figure 2 is the graph of this data, and both Figures 1 and 2 demonstrate the variability of precipitation from station to station and from year to year. Figure 2 will be referenced frequently in this report.

Figure 3 has been included to account for an unusual storm that occurred during late-September and early-October of 1984. Climatologists explain the cause of that storm as the warming of the Pacific Ocean waters, or the El Nino Southern Oscillation. It is estimated that the storm had a re-occurrence frequency of approximately 500 years. That six-to-seven-day storm produced very heavy flooding throughout the area, including the San Simon watershed.

Fortunately, the equipment was able to record excellent data throughout the duration of that storm. The two-month precipitation ranged from 5.79 inches at San Simon, located in the interior of the watershed, to 7.54 inches at the University of Arizona Weather Station in Lone Star.

Stormflow Data, Barrier Dam

Table 3 contains the summary of stormflow data collected at Barrier Dam, in acre-feet of flow. The last column shows the total number of days of sustained flow during each water year. [See Appendix B for complete monthly and yearly summary of stormflow by CFS, Acre-feet, and Maximum Flow for each year].

The quantity of flow that occurred in September and October of 1984, due mainly to El Nino, was 10,935 acre-feet, or 90 percent of the entire year's volume. The total volume of flow for the year was 12,112.3 acre-feet, which was the highest for the period of

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Table 1 **Weather Bureau & BLM Raingages, San Simon Watershed**

1983	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.67	1.16	1.61	0.15	0.00	0.02	2.49	1.14	2.99	3.02	2.04	0.86	17.15
San Simon	0.83	1.00	1.10	0.00	0.00	0.05	2.25	1.07	3.74	2.05	2.05	0.51	14.65
Lone Star	1.11	1.15	1.69	0.05	0.00	0.03	3.24	0.51	3.77	3.77	0.91	1.14	17.37
Tanque	1.17	1.37	2.13	0.06	0.00	0.02	2.22	0.70	3.55	3.15	1.32	0.58	16.27
Howard Wel	1.34	1.30	1.11	0.06	0.16	0.00	2.06	0.76	3.71	3.13	1.74	0.68	16.05
Ash Peak							3.73	1.06	2.99	4.34	2.99	1.18	
Avg. Precip	1.22	1.20	1.53	0.06	0.03	0.02	2.67	0.87	3.46	3.24	1.84	0.83	16.97
# of Stat.	5	5	5	5	5	5	6	6	6	6	6	6	
1984	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.09	0.00	0.00	0.52	0.11	0.35	1.63	3.00	0.39	2.27	0.26	2.96	12.58
San Simon	0.51	0.00	0.00	0.36	0.17	0.76	3.19	3.33	0.51	1.59	0.66	1.29	12.37
Lone Star	1.21	0.00	0.00	0.56	0.77	0.91	3.24	3.16	1.15	0.42	0.20	2.31	13.93
Tanque	1.57	0.01	0.00	0.54	0.56	0.53	1.46	2.72	1.65	1.21	0.29	2.90	13.44
Howard Wel	0.33	0.00	0.00	0.66	0.00	0.39	1.30	2.39	0.70	1.97	0.32	2.29	10.34
Ash Peak	1.13	0.02	0.00	0.99	0.04	1.43	3.77	3.12	1.22	2.50	0.51	2.81	17.54
Avg. Precip	0.97	0.01	0.00	0.61	0.28	0.73	2.43	2.95	0.94	1.66	0.37	2.43	13.37
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	
1985	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.36	0.78	0.61	0.97	0.30	0.07	0.63	2.70	2.26	3.67	1.04	0.16	14.55
San Simon	0.90	0.56	0.72	0.92	0.39	0.40	3.43	2.51	2.24	3.02	0.73	0.04	15.86
Lone Star	0.75	0.45	0.73	0.80	0.00	0.03	2.23	0.76	3.22	2.05	0.87	0.01	11.90
Tanque	1.20	0.71	0.56	0.91	0.12	0.37	1.26	1.96	5.13	3.00	0.84	0.19	16.25
Howard Wel	1.21	0.55	0.60	0.74	0.05	0.42	2.16	0.98	2.39	3.15	1.18	0.24	13.67
Ash Peak	1.28	0.98	1.27	0.75	0.10	0.04	3.09	1.89	2.30	2.60	1.32	0.57	16.19
Avg. Precip	1.12	0.67	0.75	0.85	0.16	0.22	2.13	1.80	2.92	2.92	1.00	0.20	14.74
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	
1986	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	0.08	1.81	1.17	0.01	0.36	0.45	1.86	1.79	0.55	2.13	1.82	2.35	14.38
San Simon	0.04	1.75	1.46	0.00	0.02	0.27	3.60						
Lone Star	0.04	1.32	1.48	0.16	0.07	0.76	1.95	1.22	0.45	1.23	2.39	0.70	11.77
Tanque	0.01	1.05	1.60	0.04	0.31	1.97	1.68	2.97	0.78	0.89	2.31	1.31	14.92
Howard Wel	0.03	1.25	1.43	0.08	0.17	0.63	2.00	2.57	0.58	1.64	1.44	2.78	14.60
Ash Peak	0.06	1.34	1.96	0.04	0.10	0.45	2.73	1.94	1.08	1.23	1.74	1.25	13.82
Avg. Precip	0.04	1.42	1.52	0.06	0.17	0.76	2.30	2.08	0.69	1.42	1.94	1.68	14.07
# of Sta.	6	6	6	6	6	6	6	5	5	5	5	5	
1987	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	0.71	1.18	0.42	1.10	1.13	0.80	1.55	3.41	0.94	0.49	0.30	2.85	14.88
San Simon	0.59	1.46	0.22	2.04	0.49	0.17	1.88	2.90	0.34	0.69	0.09	2.50	13.37
Lone Star	0.31	1.58	0.52	0.27	0.41	0.25	1.60	1.68	0.69	0.31	0.24	1.41	9.27
Tanque	0.30	1.75	0.41	0.52	0.60	1.19	1.93	2.03	1.22	0.42	0.29	1.25	11.91
Howard Wel	0.30	1.21	0.21	0.62	0.61	0.13	1.74	2.42	0.69	0.50	0.18	2.41	11.02
Ash Peak	0.43			0.60	0.60	0.24	1.94	2.54	0.62	0.26	0.65	2.16	
Avg. Precip	0.44	1.44	0.36	0.86	0.64	0.46	1.77	2.50	0.75	0.45	0.29	2.10	12.05
# of Sta.	6	5	5	6	6	6	6	6	6	6	6	6	

Table 1 (Cont) **Weather Bureau & BLM Raingages, San Simon Watershed**

1988	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	0.68	1.62	0.00	1.09	0.00	0.08	1.31	5.47	0.69	2.59	0.38	0.18	14.09
San Simon	0.88	0.91	0.09	0.89	0.00	0.11	1.67	6.14	1.55	1.78	0.53	0.57	15.12
Lone Star	0.35	1.49	0.00	1.43	0.00	0.30	0.28	2.31	0.88	1.26	0.51	0.35	9.16
Tanque	0.42	1.56	0.00	1.01	0.00	0.27	2.50	2.05	0.76	1.90	0.61	0.34	11.42
Howard Well	0.43	1.25	0.04	1.18	0.00	0.30	1.50	2.19	0.65	1.67	0.54	0.22	9.97
Ash Peak	0.75	1.31	0.00	1.03	0.00	0.28	1.63	2.00	0.63	1.66	0.61	0.39	10.29
Avg. Precip	0.59	1.36	0.02	1.11	0.00	0.22	1.48	3.36	0.86	1.81	0.53	0.34	11.68
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	
1989	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.16	0.19	0.44	0.03	0.06	0.00	1.86	3.51	0.07	2.90	0.00	0.00	10.22
San Simon	0.03	0.20	0.21	0.00	0.27	0.00	2.17	0.66	0.72	0.81	0.02	0.15	5.24
Lone Star	1.09	0.00	0.08	0.00	0.17	0.00	0.94	0.27	0.63	1.44	0.00	0.21	4.83
Tanque	1.19	0.10	0.12	0.04	0.13	0.00	1.54	0.56	0.15	2.15	0.00	0.30	6.28
Howard Well	0.82	0.04	0.23	0.00	0.17	0.00	1.80	1.87	0.42	1.95	0.00		
Ash Peak	0.87	0.04	0.20	0.02	0.44	0.00	1.74	0.24	1.20	2.05	0.00	0.18	6.98
Van Gausig			0.14	0.01	0.14	0.00	2.03	2.39	0.15	1.91	0.00	0.20	6.97
Avg. Precip	0.86	0.10	0.20	0.01	0.20	0.00	1.73	1.36	0.48	1.89	0.00	0.17	6.99
# of Sta.	6	6	7	7	7	7	7	7	7	7	7	6	
1990	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	0.64	0.71	0.49	0.16	0.41	0.44	2.53	1.62	2.34	0.94	1.94	1.98	14.20
San Simon	1.06	0.64	0.05	0.07	0.45	1.14	1.93	1.01	3.24	0.67	2.41	1.97	14.64
Lone Star	0.32	0.47	0.90	0.11	0.07	0.64	1.96	1.37	2.24	0.72	0.79	1.44	11.03
Tanque	0.21	0.20	0.42	0.12	0.08	0.34	4.31	2.31	1.41	0.72	1.16	2.39	13.67
Ash Peak	0.38	0.70	0.51	0.11	0.26	0.35	3.00	2.80	1.15	0.76	1.37	3.90	15.29
Van Gausig	0.37	0.54	0.97	0.16	0.08	0.26	4.88	2.35	1.66	1.07	1.38	2.42	16.14
Avg. Precip	0.50	0.54	0.56	0.12	0.23	0.53	3.10	1.91	2.01	0.81	1.51	2.35	14.16
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	
1991	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.72	1.46	1.28	0.00	0.17	0.08	2.64	2.07	0.89	0.14	1.55	4.01	16.01
San Simon	1.13	1.82	1.10	0.00	0.00	0.95	1.11	1.71	1.54	0.40	0.97	5.40	16.13
Lone Star	0.61	1.16	1.71	0.00	0.00	0.02	1.07	2.82	0.29	0.25	0.31	4.14	12.38
Tanque	0.85	1.30	1.49	0.00	0.00	0.00	1.39	4.10	0.15	0.49	0.54	4.50	14.81
Ash Peak	0.98	1.48	1.97	0.00	0.14	0.00	1.67	3.59	1.76	0.35	1.35	4.30	17.59
Van Gausig	0.92	2.20	2.25	0.00	0.05	0.02	2.06	4.56	0.41	0.48	0.88	4.86	18.69
Avg. Precip	1.04	1.57	1.63	0.00	0.06	0.18	1.66	3.14	0.84	0.35	0.93	4.54	15.93
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	

Table 1 (Cont) **Weather Bureau & BLM Raingages, San Simon Watershed**

1992	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.14	1.50	1.47	0.43	3.03	0.72	2.28	3.56	0.61	0.90	0.13	2.32	18.09
San Sim	0.36	1.39	1.55	1.16	0.80	0.00	3.25	0.75	0.85	1.10	0.00	2.74	13.95
Lone Star	0.98	1.16	1.66	0.40	2.28	0.26	1.38	4.34	0.13	0.10	0.04	2.39	15.12
Tanque	1.27	1.22	1.13	0.67	2.91	0.30	0.85	3.00	0.32	0.55	0.16	2.96	15.34
Ash Peak	1.03	1.80	1.36	0.65	3.48	0.56	0.85	2.53	0.45	0.79	0.02	2.73	16.25
Van Gausig	1.58	1.73	2.05	0.38	2.64	0.46	0.63	3.66	0.60	0.61	0.52	3.97	18.83
Avg. Precip	1.06	1.47	1.54	0.62	2.52	0.38	1.54	2.97	0.49	0.68	0.15	2.85	16.26
# of Sta.	6	6	6	6	6	6	6	6	6	6	6	6	
1993	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	4.09	0.99	0.39	0.00	0.52	0.00	1.30	3.75	0.03	1.15	1.06	0.37	13.65
San Simon	5.41	1.49	0.04	0.00	0.00	0.00	0.12	2.73	0.00	0.41	0.91	0.34	11.45
Lone Star	3.09	1.11	0.35	0.00	0.05	0.26	0.54	2.22	0.21	1.17	0.63	0.19	9.82
Tanque	3.75	1.82	0.30	0.00	0.00	0.00	0.29	5.32	0.18	1.86	0.71	0.14	14.37
Ash Peak	4.27	2.01	0.39	0.00	0.05	0.00	0.68	4.34					
Van Gausig	4.35	1.90	0.38	0.00	0.25	0.00	0.45	5.20	0.36	1.77	1.08	0.16	15.90
Avg. Precip	4.16	1.55	0.31	0.00	0.15	0.04	0.56	3.93	0.16	1.27	0.88	0.24	13.25
# of Sta.	6	6	6	6	6	6	6	6	5	5	5	5	
1994	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	0.27	0.36	0.83	0.06	0.51	0.35	2.30	1.77	1.25	0.64	2.28	3.49	14.11
San Simon	0.13		0.50	0.38	0.28	0.00	3.93	0.76	0.04	0.89	1.81	2.65	
Lone Star	0.09	0.68	0.62	0.22	0.35	0.16	0.77	1.61	0.81	0.74	1.77	1.71	9.53
Tanque	0.13	0.49	0.78	0.00	0.62	0.21	1.12	1.71	1.08	0.39	2.25	3.10	11.88
Van Gausig	0.08	0.77	1.05	0.20	0.72	0.74	1.03	1.60	0.91	0.56	3.11	3.95	14.72
Avg. Precip	0.14	0.58	0.76	0.17	0.50	0.29	1.83	1.49	0.82	0.64	2.24	2.98	12.44
# of Sta.	5	4	5	5	5	5	5	5	5	5	5	5	
1995	Jan	Feb.	March	April	May	June	July	Aug.	Sept	Oct	Nov	Dec	Tot. Precip
Bowie	1.25	1.45	0.23	0.16	0.03	0.00	1.10	2.66	0.71	0.08	0.60	0.77	9.04
San Simon	1.59	1.36	0.47	0.16	0.00	0.00	1.34	3.42	1.61	0.00	0.35	0.42	10.72
Lone Star	1.30	0.89	0.37	0.06	0.12	0.01	0.25	3.54	1.06	0.00	0.36	0.13	8.09
Tanque	1.98	2.07	0.18	0.06	0.07	0.04	0.28	1.18	2.03	0.01	0.33	0.05	8.28
Van Gausig	2.60	1.75	0.50	0.08	0.11	0.13	0.48	2.78	3.32	0.00	0.45	0.18	12.38
Avg. Precip	1.74	1.50	0.35	0.10	0.07	0.04	0.69	2.72	1.75	0.02	0.42	0.31	9.70
# of Sta.	5	5	5	5	5	5	5	5	5	5	5	5	

Figure 1 **Weather Bureau & BLM Raingages, San Simon Watershed**

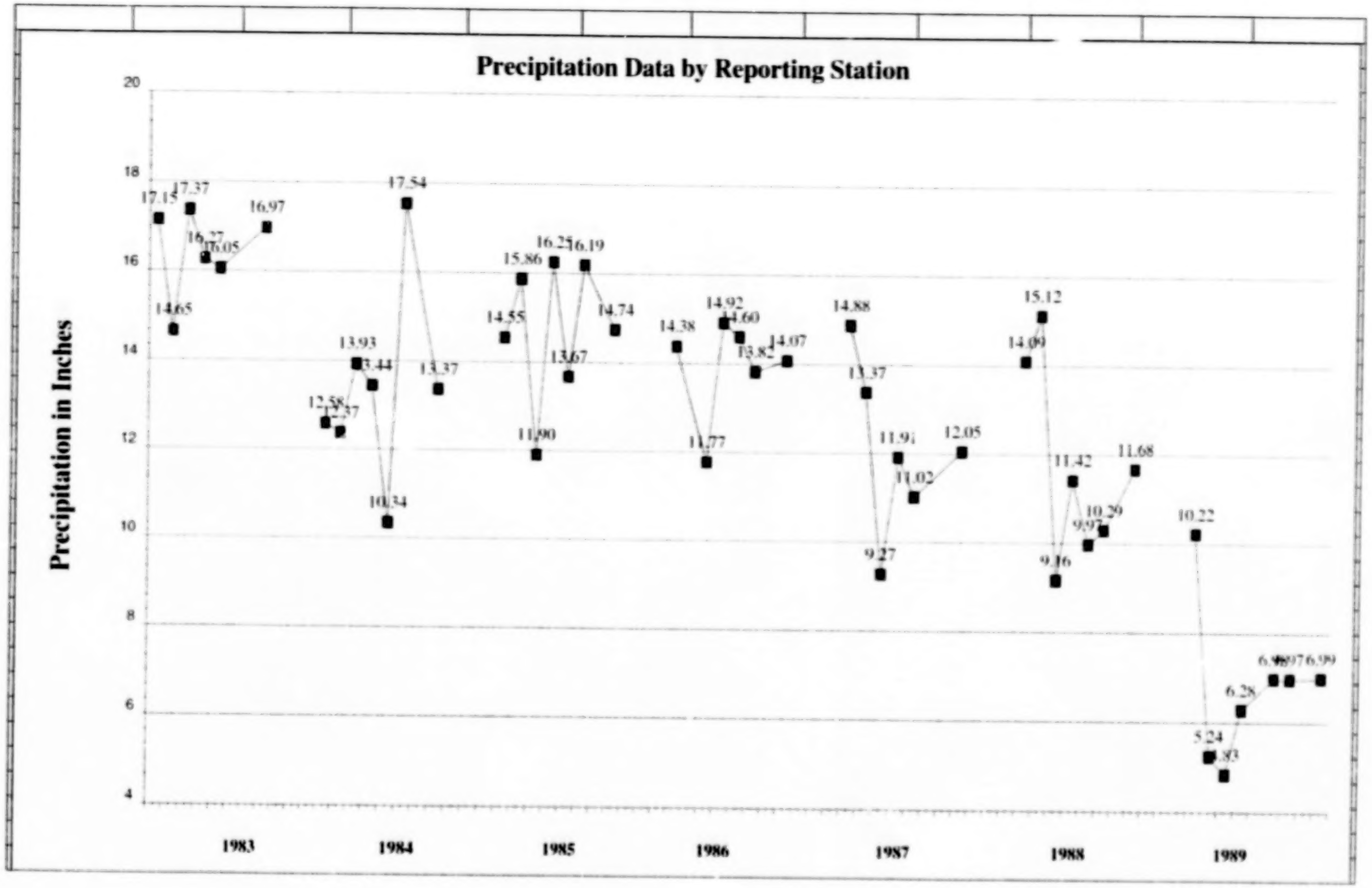
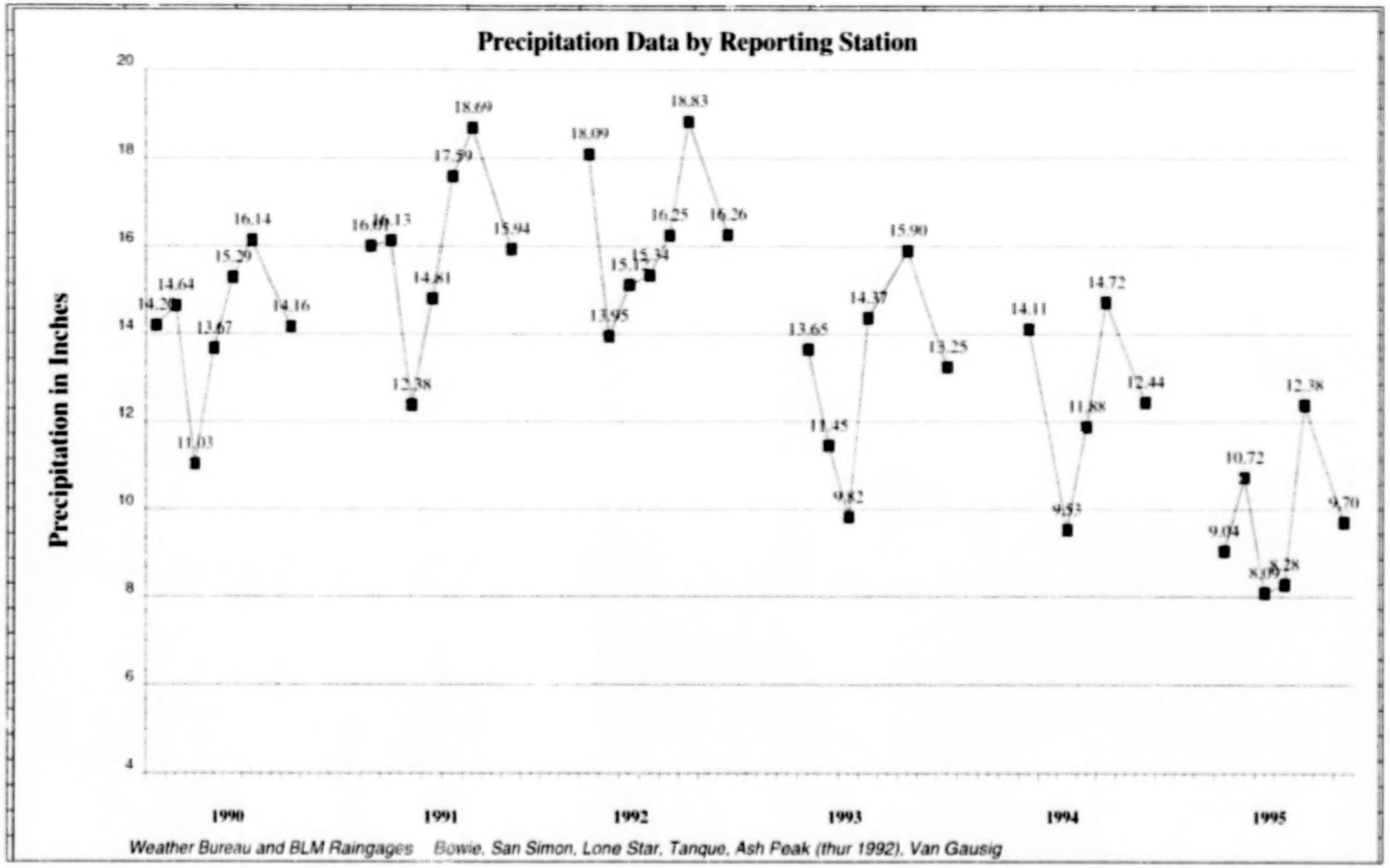


Figure 1 (Cont.) **Weather Bureau & BLM Raingages, San Simon Watershed**



Weather Bureau and BLM Raingages Bowie, San Simon, Lone Star, Tanque, Ash Peak (thur 1992), Van Gausig

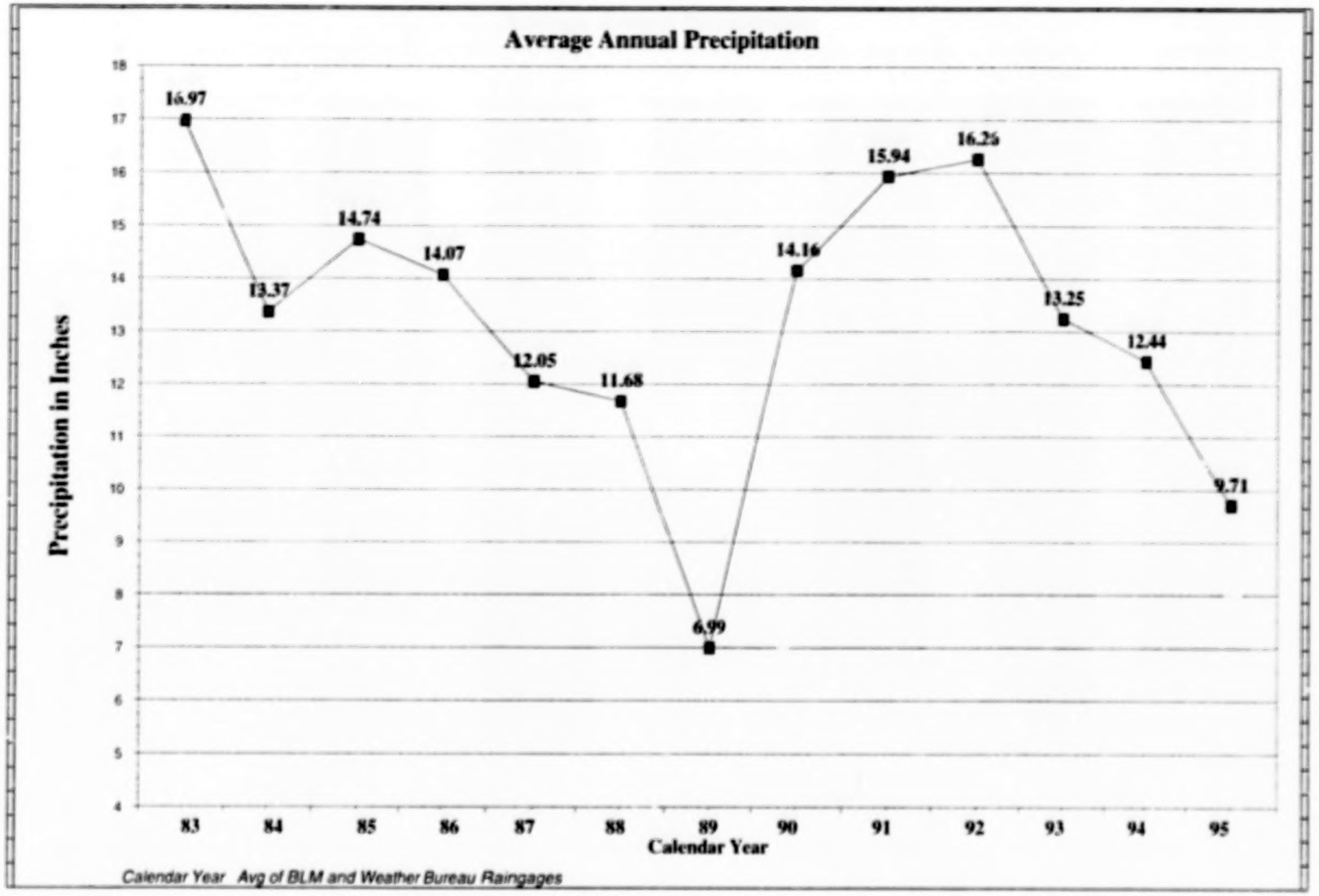
Table 2

Precipitation, San Simon Watershed

Precipitation data 1983-1995 (Averaged from Weather Bureau and BLM Gages)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg. Total	No. Gages
83	1.22	1.20	1.53	0.06	0.03	0.02	2.67	0.87	3.46	3.24	1.84	0.83	16.97	6
84	0.97	0.01	0.00	0.61	0.28	0.73	2.43	2.95	0.94	1.66	0.37	2.43	13.37	6
85	1.12	0.67	0.75	0.85	0.16	0.22	2.13	1.80	2.92	2.92	1.00	0.20	14.74	6
86	0.04	1.42	1.52	0.06	0.17	0.76	2.30	2.08	0.69	1.42	1.94	1.68	14.08	6
87	0.44	1.44	0.36	0.86	0.64	0.46	1.77	2.50	0.75	0.45	0.29	2.10	12.05	6
88	0.59	1.36	0.02	1.11	0.00	0.22	1.48	3.36	0.86	1.81	0.53	0.34	11.68	6
89	0.86	0.10	0.20	0.01	0.20	0.00	1.73	1.36	0.48	1.89	0.00	0.17	6.99	7
90	0.50	0.54	0.56	0.12	0.23	0.53	3.10	1.91	2.01	0.81	1.51	2.35	14.16	6
91	1.04	1.57	1.63	0.00	0.06	0.18	1.66	3.14	0.84	0.35	0.93	4.54	15.94	6
92	1.06	1.47	1.54	0.62	2.52	0.38	1.54	2.97	0.49	0.68	0.15	2.85	16.26	6
93	4.16	1.55	0.31	0.00	0.15	0.04	0.56	3.93	0.16	1.27	0.88	0.24	13.25	6
94	0.14	0.58	0.76	0.17	0.50	0.29	1.83	1.49	0.82	0.64	2.24	2.98	12.44	5
95	1.74	1.5	0.35	0.10	0.07	0.04	0.69	2.72	1.75	0.02	0.42	0.31	9.71	5
Monthly Avg	1.07	1.03	0.73	0.35	0.38	0.30	1.84	2.39	1.24	1.32	0.93	1.62	13.20	

Figure 2 **Precipitation, San Simon Watershed**



Calendar Year Avg of BLM and Weather Bureau Raingages

Figure 3 **Precipitation, San Simon Watershed**

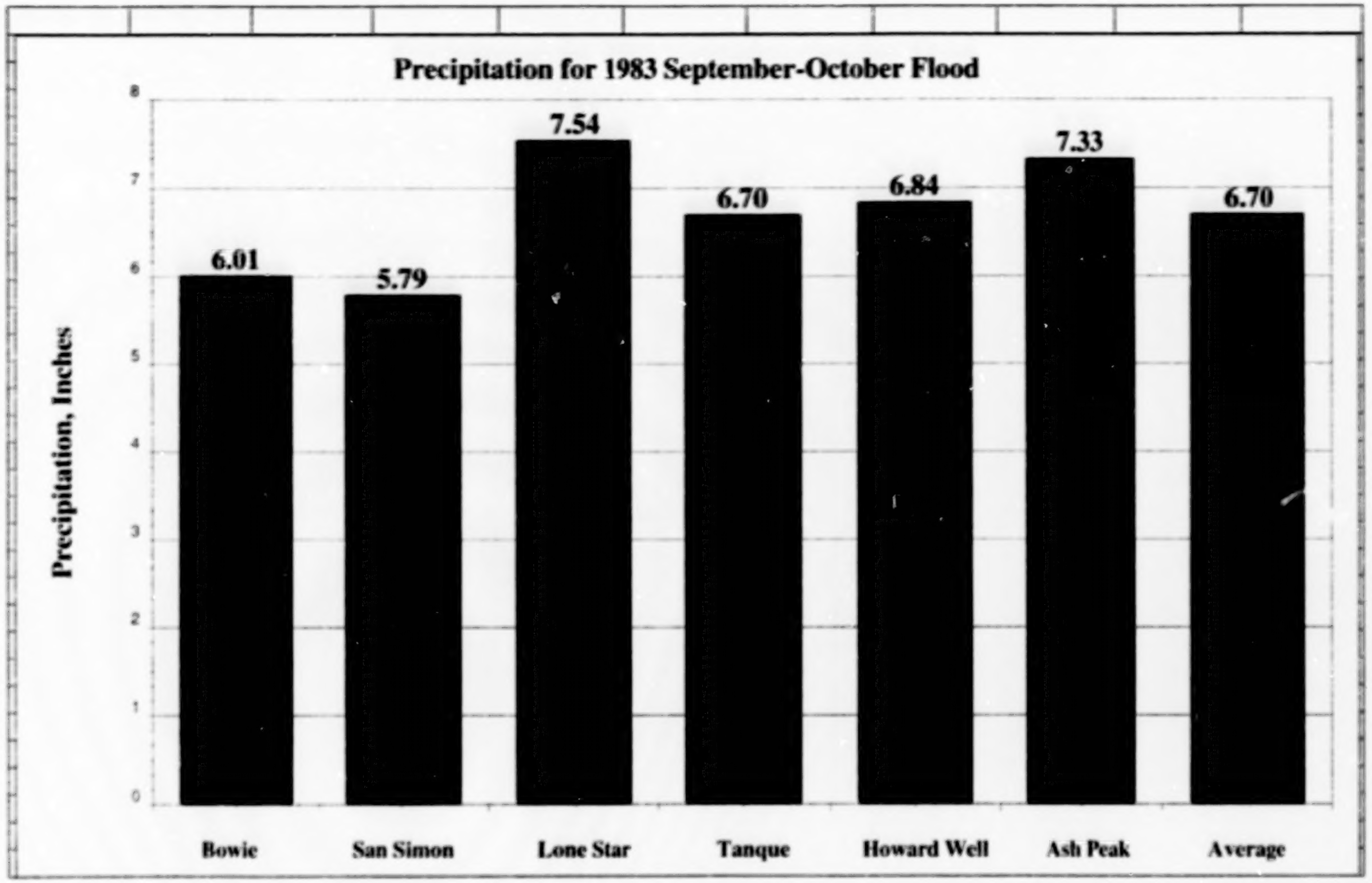


Table 3

San Simon Stormflow, Barrier Dam

Stormflow Data at Barrier Dam 1983-1995

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Ac-ft	Days of Flov
83	34.9	340.8	52.1	0.0	0.0	0.0	118.5	570.8	1149.0	9786.0	42.9	17.3	12112.3	50
84	58.2	0.0	0.0	0.0	34.9	418.7	1368.0	742.8	146.3	111.0	0.0	215.0	3094.9	55
85	27.2	0.0	17.2	30.9	0.0	0.0	638.4	333.5	1576.0	1997.7	0.0	0.0	4620.9	55
86	0.0	100.0	28.5	0.0	0.0	160.5	404.8	1015.7	122.2	84.2	508.6	68.0	2492.5	51
87	0.0	40.1	0.0	0.0	19.5	34.9	24.2	201.9	59.9	6.1	81.9	174.9	643.4	33
88	0.0	68.6	0.0	0.0	0.0	0.6	85.9	2301.3	734.5	131.0	0.0	0.0	3321.9	43
89	8.5	0.0	0.0	0.0	0.0	0.0	153.8	84.7	2.4	1003.0	0.0	0.0	1252.4	17
90	0.0	0.0	0.0	0.0	0.0	0.0	404.8	449.4	142.2	115.4	160.8	285.3	1557.9	37
91	0.0	13.3	11.3	0.0	0.0	0.0	52.2	439.7	116.5	0.0	0.0	1591.0	2224.0	28
92	0.0	60.8	57.4	95.5	135.1	0.6	107.7	314.1	34.9	0.0	0.0	46.6	852.7	37
93	898.3	1.0	0.0	0.0	0.0	0.0	67.6	691.1	51.5	69.8	40.1	0.0	1819.4	33
94	0.0	0.0	6.1	0.0	0.0	40.1	62.4	229.6	216.1	0.0	169.4	222.3	946.0	28
95	234.6	95.1	0.0	0.0	0.0	0.0	0.0	23.3	43.9	0.0	0.0	0.0	396.9	23

record. The next largest volume of flow was 4,620.2 acre-feet in 1985.

Figure 4 is a graph of the yearly stormflow: the precipitation graph is included on the same page to simplify comparison. The stormflow graph shows the flows decreasing over time, even when the precipitation regime increased from 1990 through 1992.

Figure 4A shows this relationship. When a running average of the data is computed and drawn on the stormflow chart from Figure 4, it reveals the steady decline in runoff over the period of record. The reasoning for this occurrence will be discussed later. [Note: The data for 1983 was excluded because of it's extraordinary status as a storm with a potential re-occurrence of 500 years]

The high volume of flow in 1983 was the result of 16.97 inches (average) of precipitation, of which 4.5 to 6.0 inches (dependent upon locality) occurred during the five-to-seven day El Nino event. In 1991, the area received an average of 15.94 inches of precipitation which produced only 2,478.7 acre-feet of stormflow.

In January of 1993, flooding occurred throughout Arizona. Flood waters cascaded down the Gila River toward the Colorado River. Streams in southeast Arizona tended to overflow, except the San Simon River. The peak flow at Barrier Dam was 100 cubic feet per second (cfs). The peak flow since then has not exceeded 97 cfs.

The number of stormflow days per year is displayed in Figure 5, with the precipitation data super-imposed on the line graph. This chart indicates a gradual decrease in flow days over the period of record. Although 1992 produced the second highest amount of precipitation, 16.26 inches (0.71 inches less than in 1983), it ranked fifth/sixth in number of flow days (37 days).

Sediment Data, Barrier Dam

The sediment data discussed here refers only to sediment particles capable of being suspended in a watery solution as part of the active stormflow. (See the Appendix for discussion of suspended sediment and the method of computation)

Table 4 contains the monthly and yearly totals of suspended sediment collected at the Barrier Dam spillway. Calendar year 1983 produced the largest loss of sediment from the watershed for the 13 years of data collected. As stated earlier, this was due mainly to the September-October flood of 1983. This flood produced 90 percent of that year's stormflow and 90 percent of the sediment yield.

As previously indicated, 1991 had nearly as much precipitation as 1983, but exceedingly less stormflow. When the sediment data is examined, 1991 had nearly one-fifth of the soil loss experienced during 1983: 45.41 ac-ft as opposed to 230.13 ac-ft. Figure 6 displays this difference graphically and is very similar in

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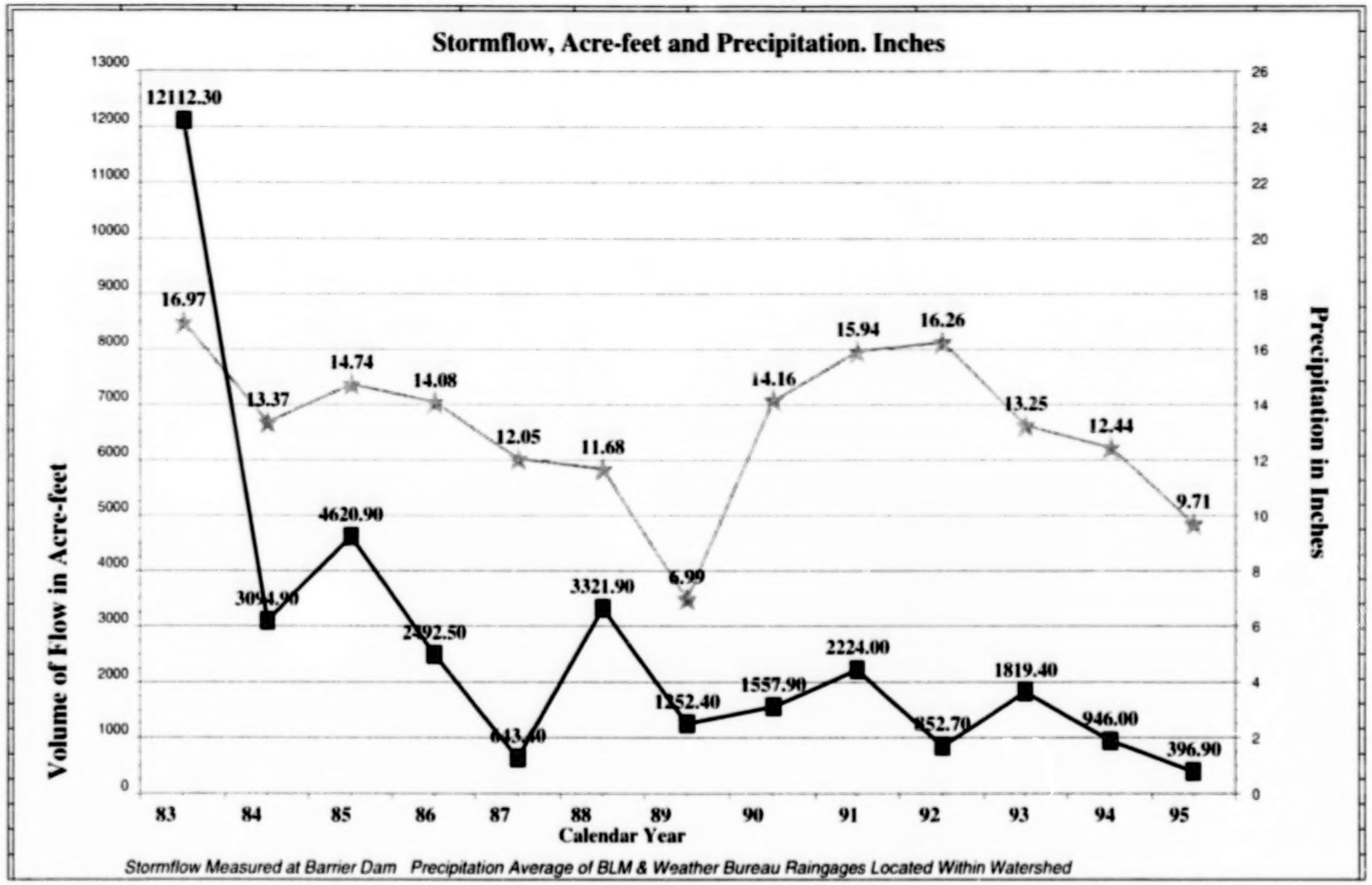
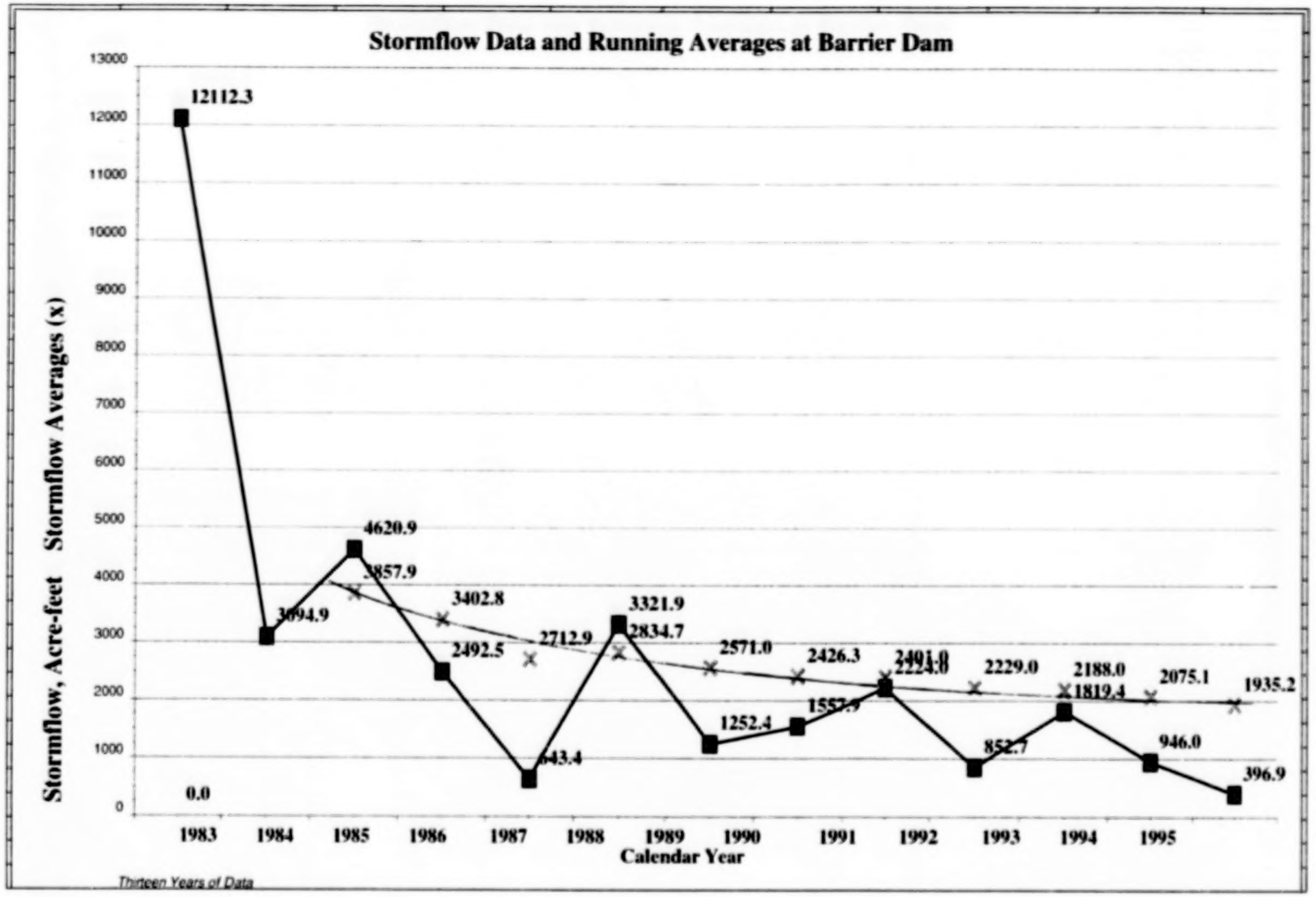
Figure 4 **San Simon Stormflow, Barrier Dam**



Stormflow Measured at Barrier Dam Precipitation Average of BLM & Weather Bureau Raingages Located Within Watershed

Figure 4A **San Simon Stormflow, Barrier Dam**



Thirteen Years of Data

Figure 5

Stormflow, Barrier Dam

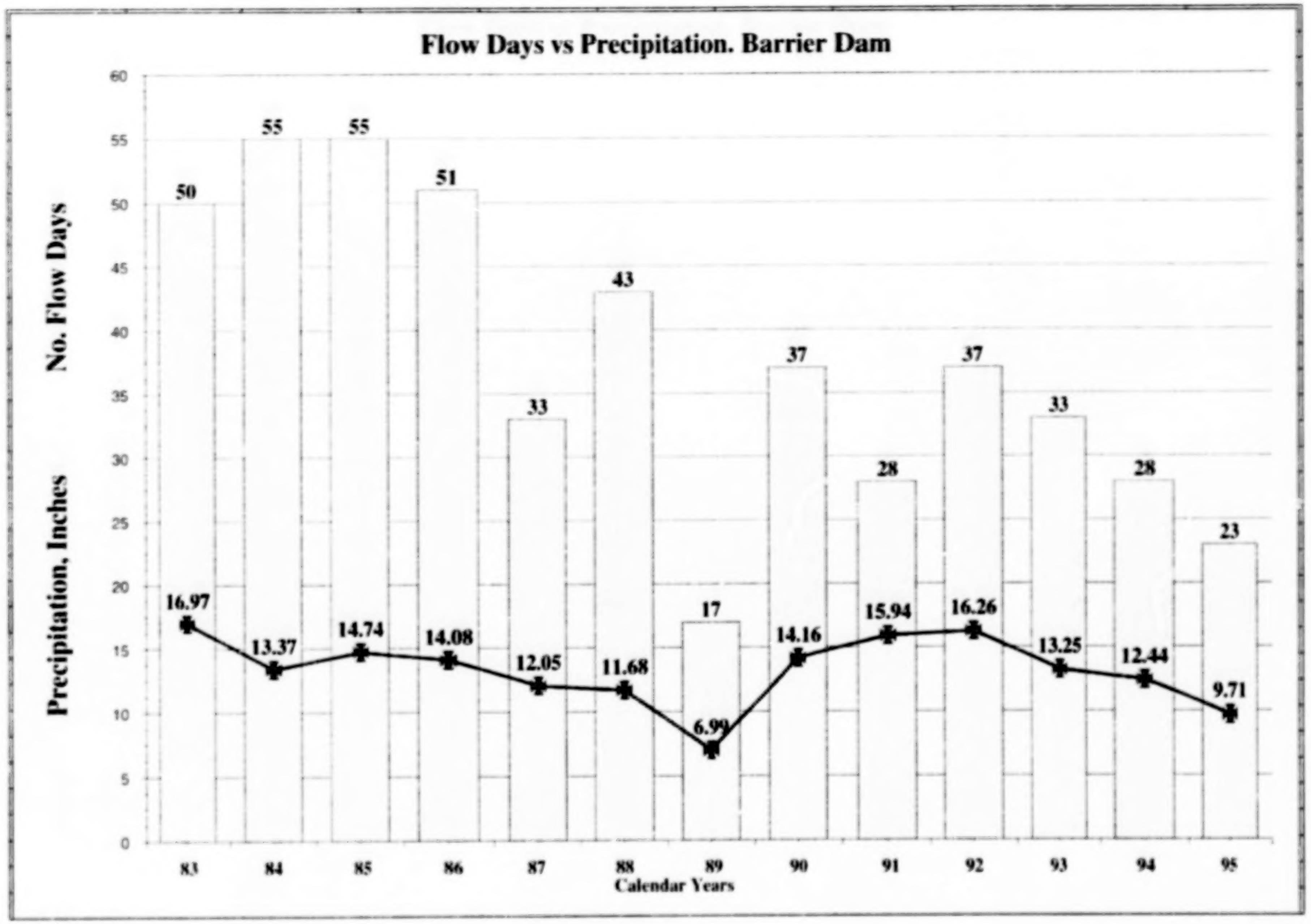
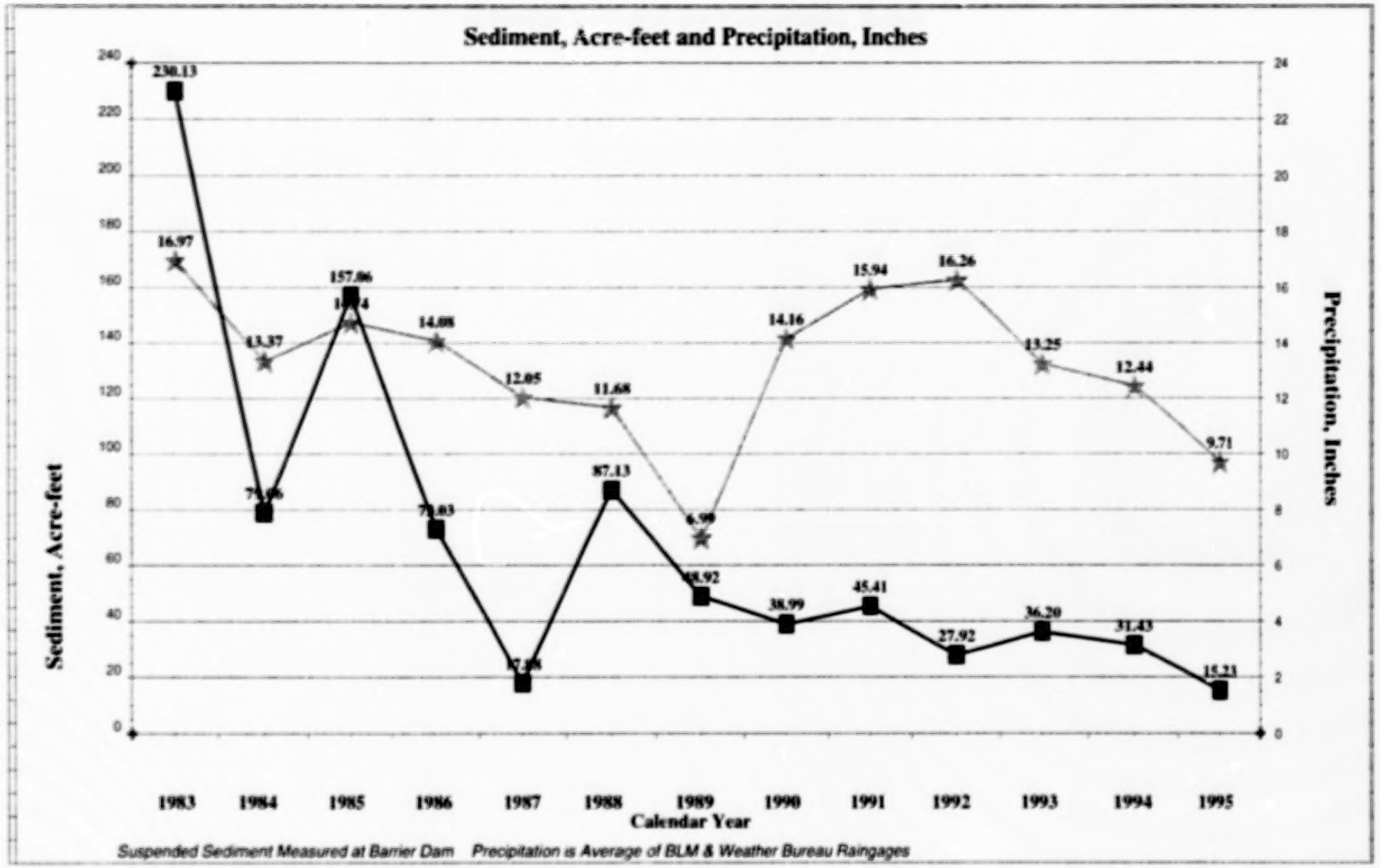


Table 4

San Simon Suspended Sediment Data

Sediment data 1983-1995 (Ac-ft)			Barrier Dam										
Year	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total Ac-ft**
83	0.86	4.15	0.95	0.00	0.00	0.00	1.63	13.53	30.58	177.78	0.44	0.21	230.13
84	1.34	0.00	0.00	0.00	0.42	15.30	34.96	15.26	5.39	2.94	0.00	3.45	79.06
85	0.20	0.00	0.11	0.36	0.00	0.00	22.52	25.44	54.75	53.68	0.00	0.00	157.06
86	0.00	2.65	0.52	0.00	0.00	3.29	9.57	33.64	2.77	1.61	17.78	1.20	73.03
87	0.00	1.05	0.00	0.00	0.42	0.76	0.64	4.98	2.88	0.05	2.04	5.06	17.88
88	0.00	1.86	0.00	0.00	0.00	0.02	3.59	53.75	24.42	3.49	0.00	0.00	87.13
89	0.12	0.00	0.00	0.00	0.00	0.00	9.00	2.13	0.02	37.65	0.00	0.00	48.92
90	0.00	0.00	0.00	0.00	0.00	0.00	8.37	9.83	4.76	4.43	5.46	6.14	38.99
91	0.00	0.37	0.14	0.00	0.00	0.00	2.06	15.03	3.01	0.00	0.00	24.80	45.41
92	0.00	2.34	0.98	4.10	2.96	0.01	3.11	12.26	1.22	0.00	0.00	0.94	27.92
93	17.92	0.01	0.00	0.00	0.00	0.00	0.88	13.35	0.42	2.45	1.17	0.00	36.20
94	0.00	0.00	0.14	0.00	0.00	1.16	2.70	6.90	2.64	0.00	10.16	7.73	31.43
95	8.93	3.03	0.00	0.00	0.00	0.00	0.00	0.54	2.73	0.00	0.00	0.00	15.23
Total													868.39

Figure 6 **San Simon Suspended Sediment Data**



Suspended Sediment Measured at Barrier Dam Precipitation is Average of BLM & Weather Bureau Raingages appearance to Figure 4, which contains stormflow data.

Figure 6A is the computation and plot of a running average of the sediment data superimposed over the plotted sediment data from Figure 6. Comparison of the running averages in Figures 4A and 6A reveals similar declining slopes, a continuous reduction of both stormflow and suspended sediment yield from the watershed [Note: The slope for sediment appears to display a little steeper decline than the slope for stormflow.]

In Figure 7, the suspended sediment concentration, or ratio of sediment yield (in acre-feet) to stormflow (in acre-feet) for each calendar year of record, has been graphed. The ratio is an indication of sediment particles gathered and retained in suspension during any flow period and summed for the year. To measure this ratio for each year's stormflows, the concentration was computed by dividing the sediment yield by the stormflow volume. The ratios varied from 0.0190 in 1983 to 0.0391 in 1989.

As stormflow commences, the increasing water turbulence collects various-sized sediment particles and holds them in suspension. The initial peak flow will usually accumulate a heavier concentration of sediment due to the effect of roil, the stirring up of sediment and debris through increasing turbulence, which can be caused by roughness of the streambed, the forward rolling movement of the water, and the growth or collection of vegetation or debris along the edge of the channel and extending into the flow. As the quantity of flow recedes, the heavier sediments (various-sized sands and flocculated silts and clays) drop out of suspension. When flow declines to a few cubic feet per second (cfs), the only soil particles remaining in suspension are the unflocculated clays, which usually give the water a milky appearance.

As discussed earlier, the U.S. Geological Survey has estimated the sediment yield for a specific quantity of annual flow. The computed ratio of sediment yield to stormflow was 0.064, 61% greater than the largest ratio found during this study. This difference in the ratios was most likely caused by the construction of 13 detention dams between 1958 and 1983, with one on the main channel.

When Figure 7 is compared to the precipitation chart in Figure 2, the data points reveal an inverse relationship where extremes occur in the precipitation data. The data indicates that as precipitation quantities sharply increased or decreased, the ratio of sediment yield-to-stormflow volume decreased or increased respectively. The reasoning: when major storms occur, the duration of receding stormflow usually increases by hours or days. This sustained flow is less turbulent and carries only lighter sediment particles in solution, thereby reducing the overall concentration.

Figure 8 displays the plotting of the sediment data divided by the precipitation data. The Figure reveals that over time a unit

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Figure 6A **San Simon Suspended Sediment Data**

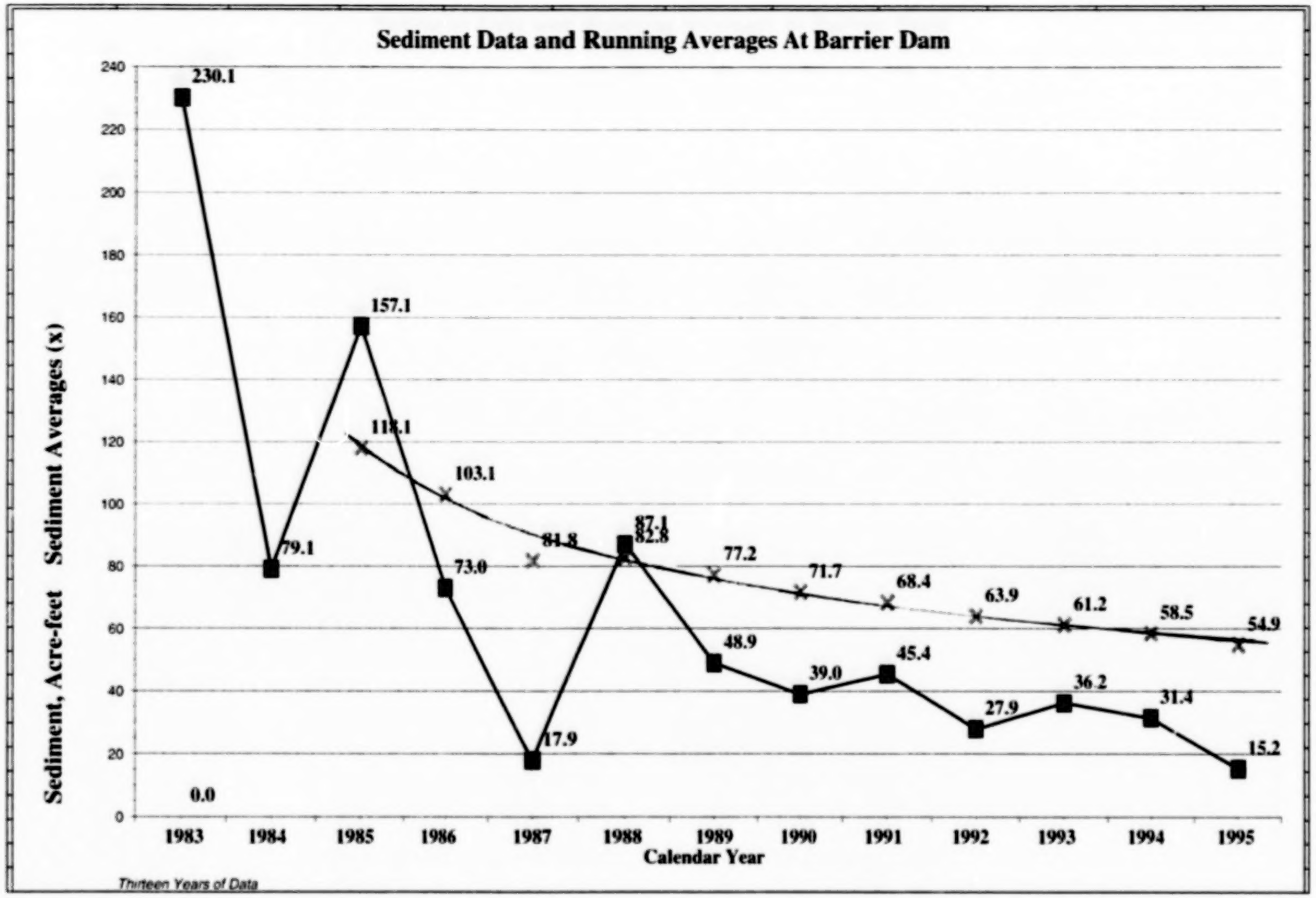


Figure 7 **San Simon Suspended Sediment Data**

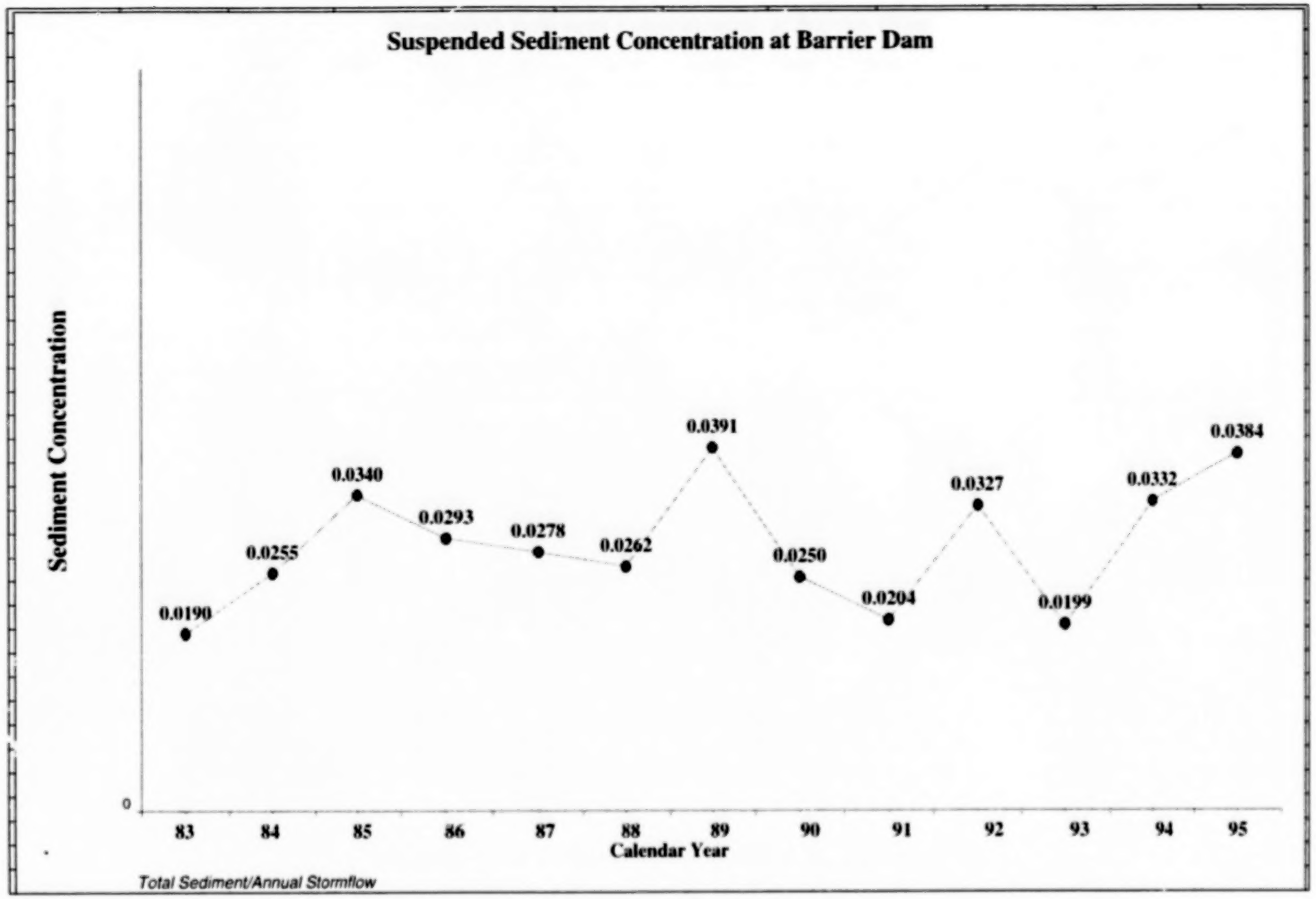
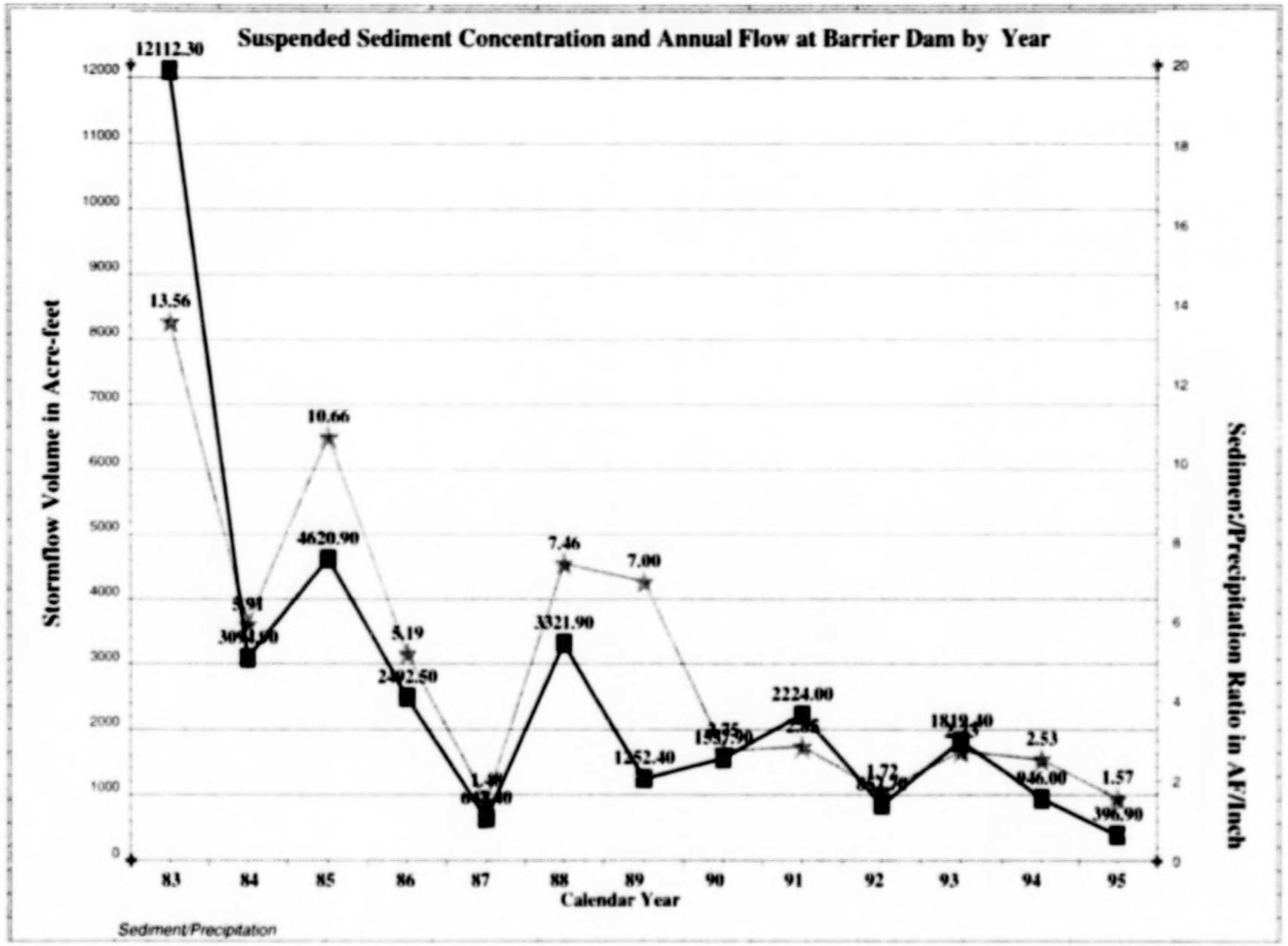


Figure 8 Suspended Sediment Data, San Simon Watershed



volume of precipitation moved less sediment each year. Note the similarities of this sediment concentration with the streamflow graph on which it has been superimposed. For the period of record, the most precipitation occurred in 1983 (16.97 inches), followed by 1992 (16.26 inches), 1991 (15.94 inches), and 1985 (15.74 inches). However, the largest volumes of sediment (and streamflow) occurred during the first (1983) and third (1985) years, while during the second (1984), ninth (1991) and tenth (1992) year both sediment and flow were greatly reduced. By the eighth, ninth and tenth years into the study, it is apparent that increased yearly precipitation has no effect on stormflow runoff and sediment yield. As was noted in several previous charts, both stormflow and the sediment yields sharply declined and appeared to level off over time. This leads one to the conclusion that improvement is actively occurring within the stream channel and the upland watershed.

Sediment Data, Bailey Well

Table 5 contains the sediment data for the Bailey Well site, separated into columns by date, parts per million (ppm) for single measurements, average for multiple measurements, the number of multiple measurements, and the ppm's for each single maximum measurement. Averages were computed for each data set by calendar year in the ppm columns.

There appears to be an extraordinary fluctuation in the 1990 and 1993 data. The data for 1990 included three measurements in excess of 100,000 ppm each, while the 1993 data contains the two measurements exceeding 300,000 plus ppm's, as discussed earlier. This fluctuation may indicate that more sediment was moving through the system during the 1990's. But, as mentioned earlier, Figures 7 and 8 show that the quantity of sediment leaving the watershed at Barrier Dam has steadily declined. Is this a contradiction, or is this additional sediment being trapped between Bailey Well and Barrier Dam? There will be more discussion on this in the channel transect section.

Figures 9 and 10 (parts 1 and 2) present sediment data taken from Table 6. A blank column separates each and the last given point for each year is the average of that data set. Whereas Figure 9 displays all the collected data, Figure 10 shows only the maximum measurements. The ppm values have been included to assist in developing an understanding for the amounts of sediment in transit within the river system.

The concentrations (ppm's) of sediment varied widely with occasional peak surges. During the 1980's, two samples exceeded 200,000 ppm (223,050 ppm in 1985 and 261,630 in 1988). Within the last six years between 1990 and the end of the study, there were two peaks that not only exceeded 200,000 ppm, but also exceeded 300,000 ppm (372,250 and 333,500 ppm, both occurring within several days of each other in 1993).

Suspended Sediment Data, Bailey Well

Table 5

1983	PPM. Avg.	No.Samples	PPM. Max	WY90	PPM. Avg.	No.Samples	PPM. Max
09/15/83	100,500		100,500	07/10/90	133,330		133,330
9/26	39,300		39,300	8/1	48,060		48,060
10/6	52,075	3	56,900	8/2	34,880		34,880
AVG.	63,958		65,567	8/21	82,600	4	119,090
1984	**PPM. Avg.**	**No.Samples**	**PPM. Max**	09/22	13,875		13,875
07/02/84	90,910		90,910	9/30	49,875	2	66,550
7/19	17,200		17,200	11/7	22,585	2	33,765
7/27	30,500	3	43,500	12/6	39,400		39,400
8/2	100,000		100,000	AVG.	53,076		61,119
8/13	44,800	4	54,000	**WY91**	**PPM. Avg.**	**No.Samples**	**PPM. Max**
8/17	30,225	3	37,600	02/13/91	17,600		17,600
8/29	36,550		36,550	7/10	47,400		47,400
10/04	48,410		48,410	7/24	48,470	3	101,800
AVG.	49,824		53,521	7/30	66,440	4	81,275
1985	**PPM. Avg.**	**No.Samples**	**PPM. Max**	8/8	60,600		60,600
07/18/85	58,400	4	69,510	8/9	53,355	2	68,215
7/21	47,600		47,600	8/14	40,050	2	40,900
8/8	35,190	4	223,050	8/26	68,835	4	100,800
09/18	42,125		42125	09/05	59,365	3	71,200
9/19	61,475	4	80,775	9/12	54,810	3	68,700
9/28	30,225	4	34,490	11/16	17,500		17,500
10/9	44,970		44,970	12/11	29,850	2	46,800
10/16	32,625		32,625	12/20	37,050	4	49,600
AVG	50,326		71,893	AVG.	46,256		59,415
WY86	**PPM. Avg.**	**No.Samples**	**PPM. Max**	**WY92**	**PPM. Avg.**	**No.Samples**	**PPM. Max**
02/10/86	35,325	2	38,660	02/02/92	39,300		39,300
6/23	29,527	2	36,300	2/13	31,300		31,300
7/15	36,875	5	55,975	3/4	38,500		38,500
8/2	78,025		78,025	3/27	69,700		69,700
8/10	46,075	2	74,635	4/2	18,000		18,000
8/27	39,625		39,625	5/5	14,300		14,300
8/29	71,600	2	71,900	5/19	115,200		115,200
10/06	43,725	2	48,960	8/6	75,550	2	85,700
10/11	39,250	2	44,260	8/21	50,615	3	66,300
11/2	45,450	5	147,900	09/20	62,875	2	84,950
12/17	22,575	2	23,333	12/7	24,800		24,800
AVG.	44,368		59,961	12/29	48,600		48,600
WY87	**PPM. Avg.**	**No.Samples**	**PPM. Max**	AVG.	49,062		53,054
07/30/87	44,075	3	66,075	**WY93**	**PPM. Avg.**	**No.Samples**	**PPM. Max**
8/3	25,875	2	26,145	01/08/93	40,120	4	71,850
8/11	74810	5	136,740	2/20	35,475		35,475
8/22	39,625	5	51,175	7/12	45,990	2	50,050
09/29	49,600	3	52,000	7/21	35,625		35,625
11/1	38,600	2	42,155	8/7	91,850		91,850
12/18	42,050	2	70,750	8/27	237,935	2	372,250
AVG.	44,948		63,577	8/31	126,260	3	333,500
WY88	**PPM. Avg.**	**No.Samples**	**PPM. Max**	10/06/93	48,075	4	54,300
02/04/88	24,360		24,360	11/15	55,200		55,200
7/19	55,575		55,575	AVG.	79,614		122,233
7/30	53425	2	61975	**WY94**	**PPM. Avg.**	**No.Samples**	**PPM. Max**
8/2	38,720	2	51,310	03/15/94	66,700		66,700
8/7	23,050	2	27,815	6/22	60,720	5	138,100
8/16	120,190	4	261,630	7/24	44,460	5	66,900
8/28	47,150		47,150	7/30	44,380	5	60,400
09/01	37,820	4	47,510	8/8	56,620	5	101,800
10/14	22,730	2	26,950	8/31	36,350		36,350
AVG.	47,002		67,142	09/03/94	36,285	2	42,800
WY89	**PPM. Avg.**	**No.Samples**	**PPM. Max**	9/12	47,410	2	50,375
01/04/89	12,760		12,760	11/13	40,910	2	45,675
7/25	40,620	4	60,980	12/5	23,710	3	37,030
7/30	38,350	3	42,685	12/26	17,110		17,110
8/1	63,270	4	78,570	AVG.	43,150		60,295
8/4	26,560		26,560	**WY95**	**PPM. Avg.**	**No.Samples**	**PPM. Max**
8/20	57,075		57,075	01/04/95	14,265		14,265
8/31	53,655		53,655	2/6	55,575		55,575
10/05	54,875	4	128,600	8/23	67,700		67,700
AVG.	43,396		57,611	8/28	68,200	2	68,650
				8/30	113,500		113,500
				9/28	35,235	2	42,120
				AVG.	59,079		60,302

Figure 9 Suspended Sediment Data, Bailey Well

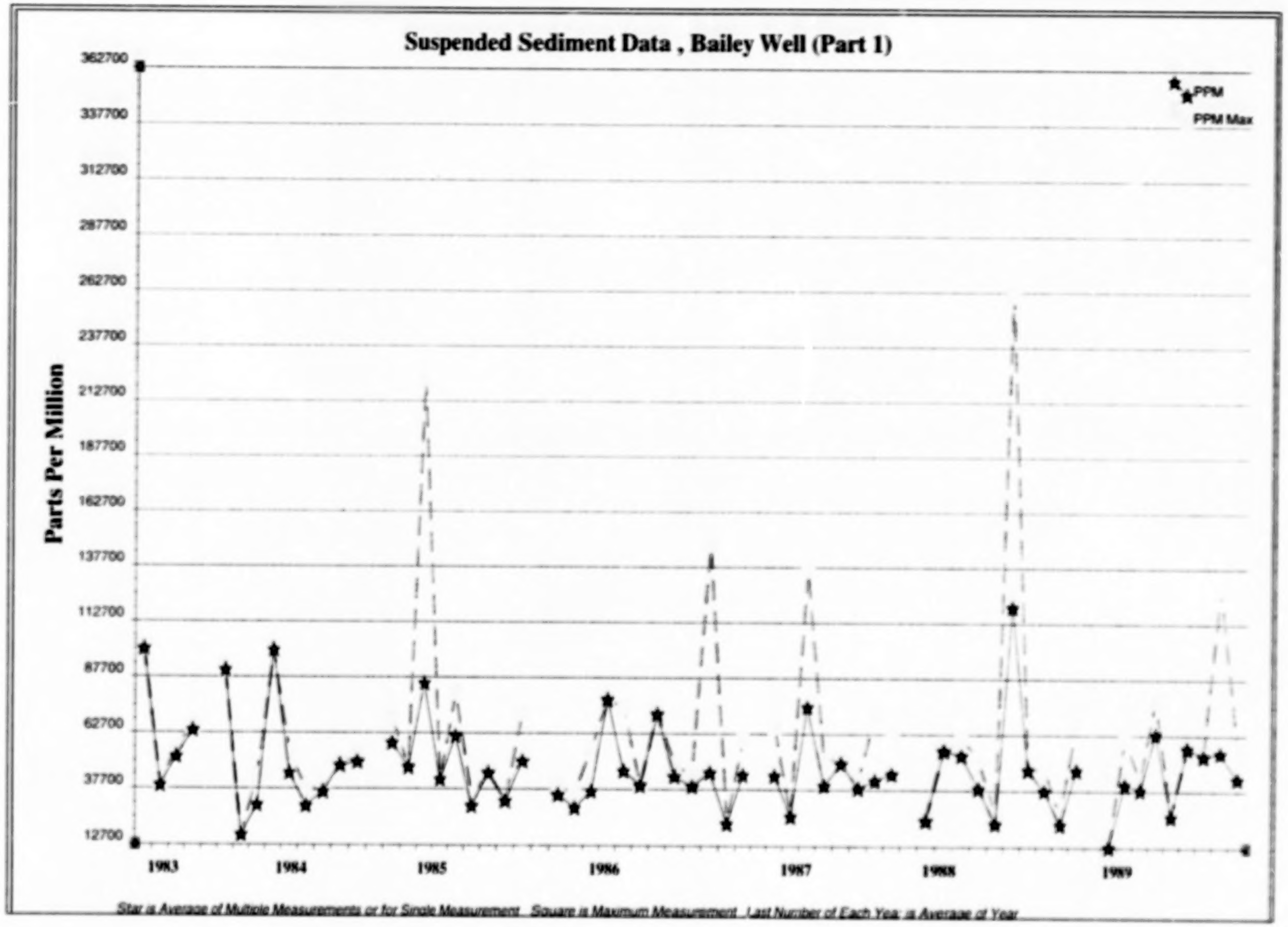


Figure 9 (Cont.) **Suspended Sediment Data, Bailey Well**

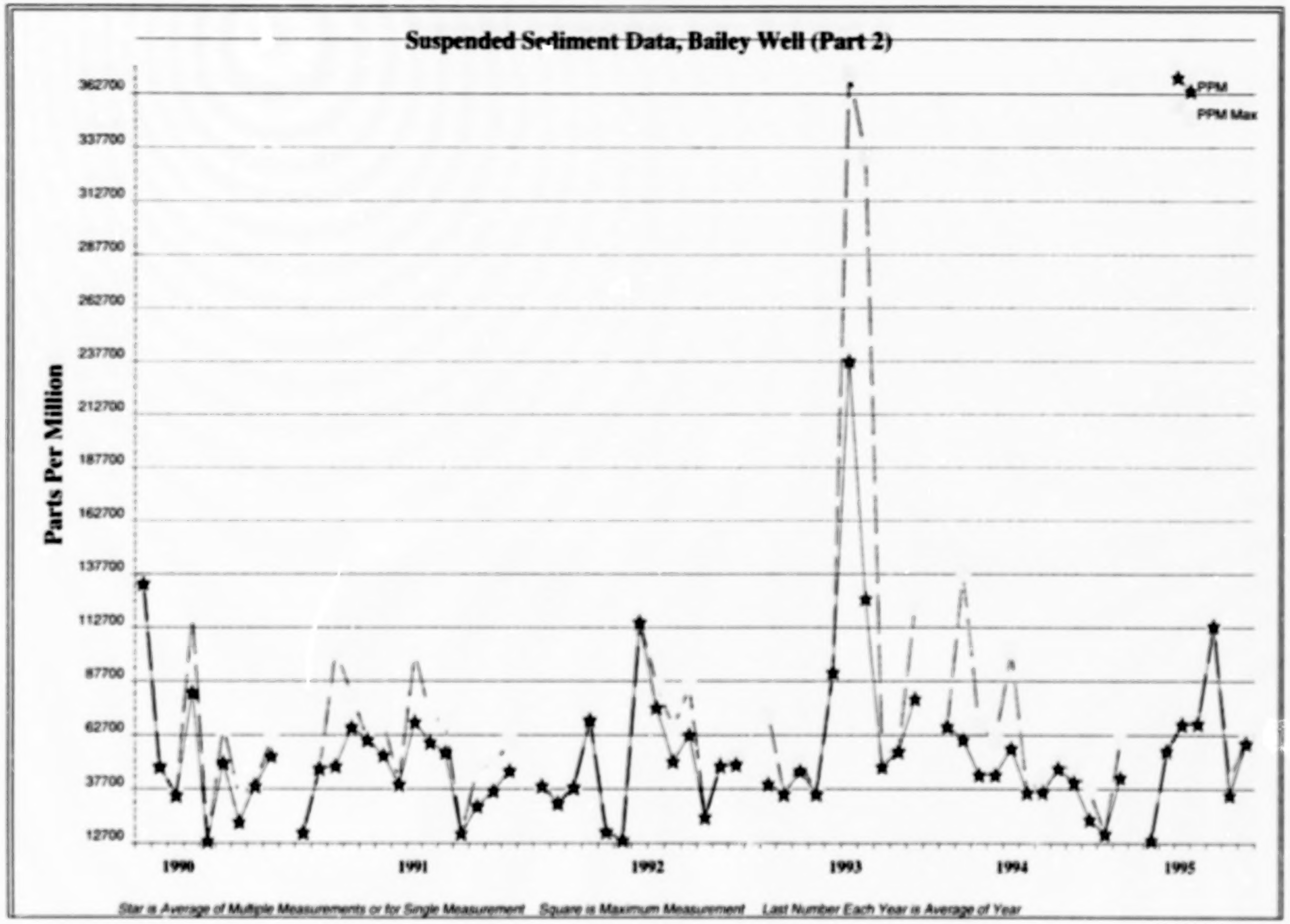


Figure 10 **Suspended Sediment Data, Bailey Well**

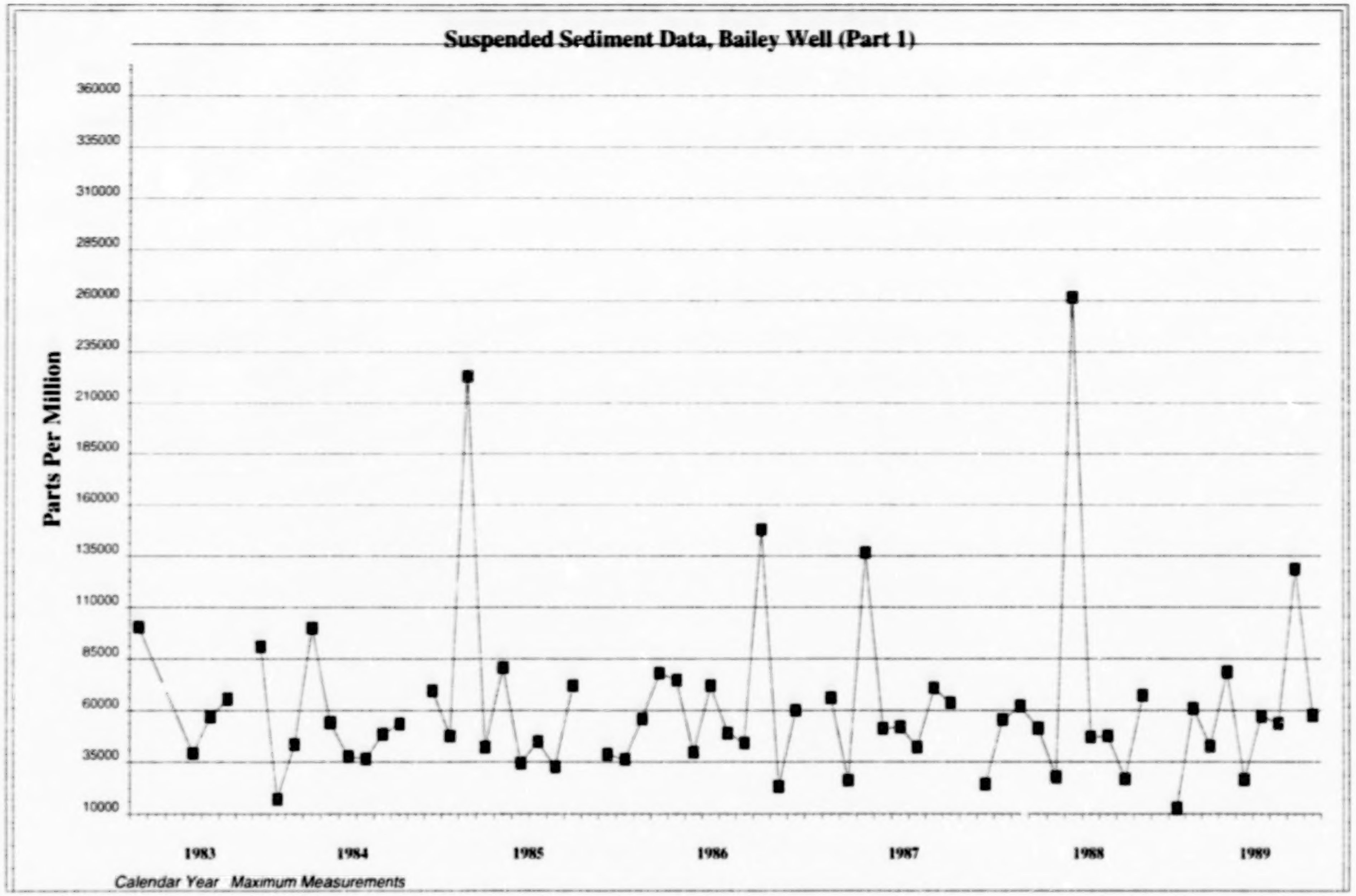
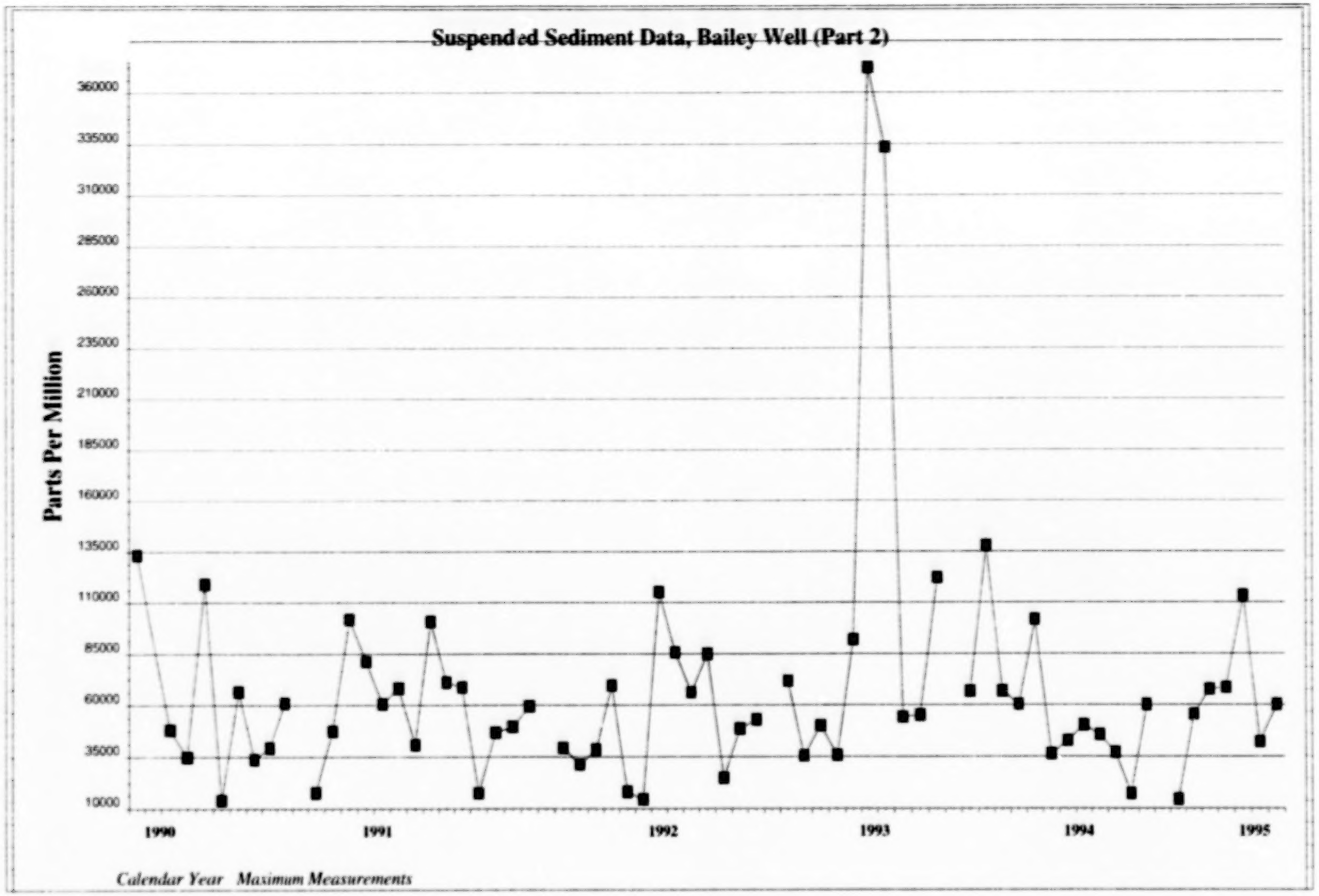


Figure 10 (Cont.) **Suspended Sediment Data, Bailey Well**



Suspended Sediment Data, Bailey Well

Table 6

Sediment Data, Bailey Well Avg of Mean & Max			
Water Year	Mean	Maximum	No. Samples
1983	63,958	65,567	5
1984	49,824	53,521	15
1985	50,326	71,893	20
1986	44,368	59,961	26
1987	44,948	63,577	22
1988	47,002	67,142	19
1989	43,396	57,611	18
1990	53,076	61,119	13
1991	46,256	59,415	31
1992	49,062	53,054	16
1993	79,614	122,233	19
1994	43,150	60,295	32
1995	59,079	60,302	8

Throughout the study period, there appears to be no specific trend in the concentrations of sediment. When the noted extremes are excluded, sediment concentration does not appear to be affected by changes in the amount of precipitation.

Figure 11 is a plot of the averages of the yearly mean and maximum sediment concentrations. The entire data set was used, allowing the extremes to skew portions of the plots. This derivation not withstanding, the figure shows the sums of the mean in comparison to the maximum measurements in the background.

Sediment Data, Fan Dam

The sediment data for Fan Dam is given in Table 7. Figure 12 shows the plot of this data. Between 1984 and 1988, sediment concentrations fluctuated from a low of 512 ppm to a high of 12,706, the highest such reading observed at Fan Dam. Fourteen samples measured in the thousands of ppm while only four measured less than one thousand ppm. Starting in 1993, one or more samples were collected each year. These samples ranged from 230 to 2250 ppm; only one sample exceeded a thousand ppm.

From these figures it may be reasonable to assume that portions of the watershed above this point have apparently begun to heal slowly, restoring the vigor of the land. The reduction in sediment concentration as indicated in the measurements would appear to lend credibility to this assumption.

For a three-year period between 1989 and 1991, no data was collected. Vandalism of the equipment twice caused the loss of data. Occasional insect habitation of the single-stage sediment sampler intakes may have caused additional losses. It was noted in the servicing log on several dates that flow had occurred or was occurring, but that it was not of sufficient depth for automatic collection of a sample. These low flows were likely the attenuation of low to moderate main channel and local tributary flows within the confines of the reservoir basin.

Streamflow Data, Fan Dam & Yellowhammer

Table 8 (5 pages) displays the history of stormflow at both Fan Dam and Yellowhammer streamgaging stations since their installation. The data is arranged in time sequence of events, with both stations on the same page, for comparison of flows within the same time frame. All hours are given in military time. Flow discharges were not computed; data is given as peak depth of flow in feet and average depth over the duration of the storm event.

Because of the distance of the two stations from the office and the condition of the roads after high-intensity or long-duration storms, some data was lost due to lack of appropriate servicing immediately after the event. On occasion equipment failure was also a factor, but such loss was minimal.

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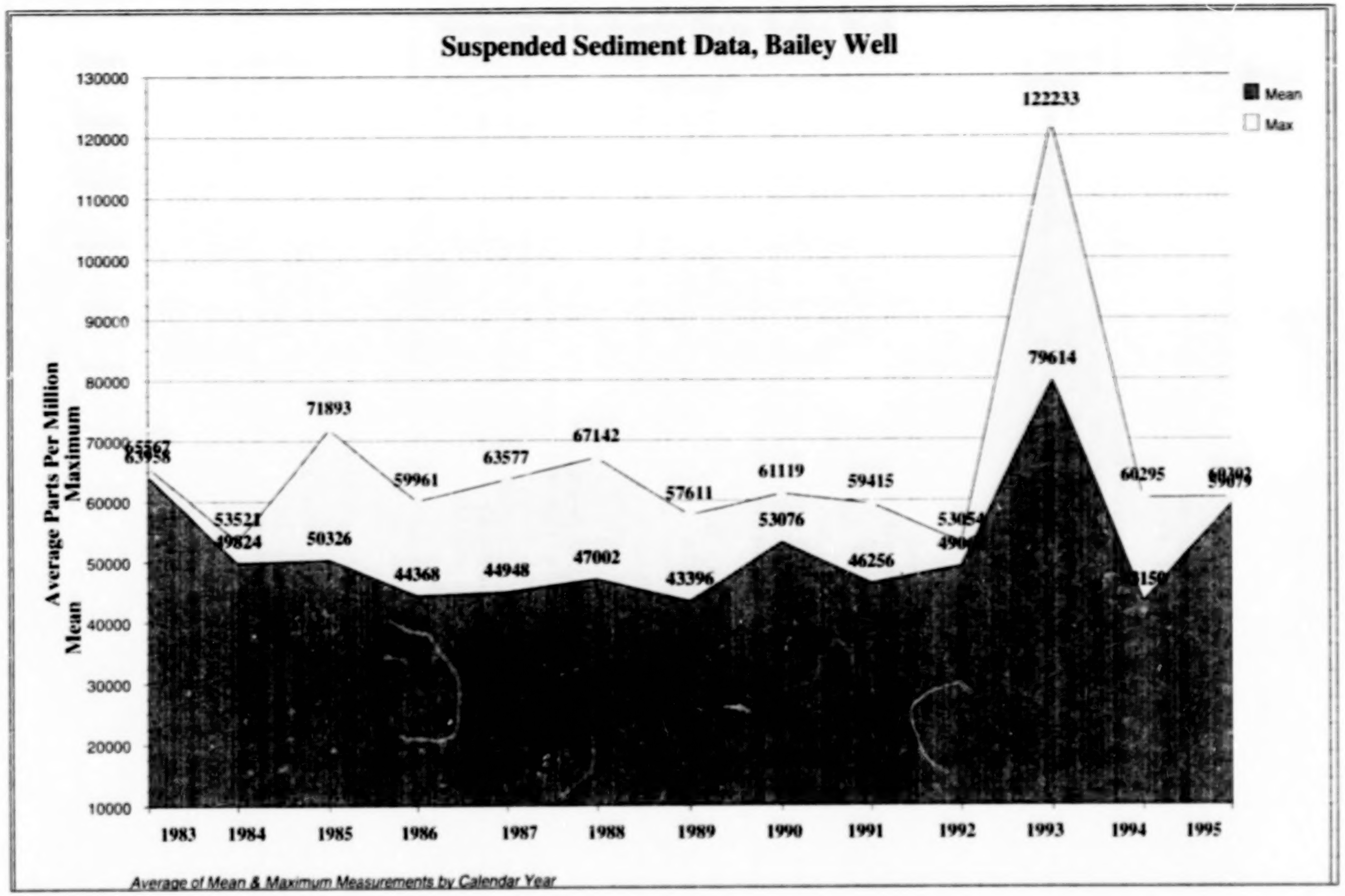
Figure 11 **Suspended Sediment Data, Bailey Well**



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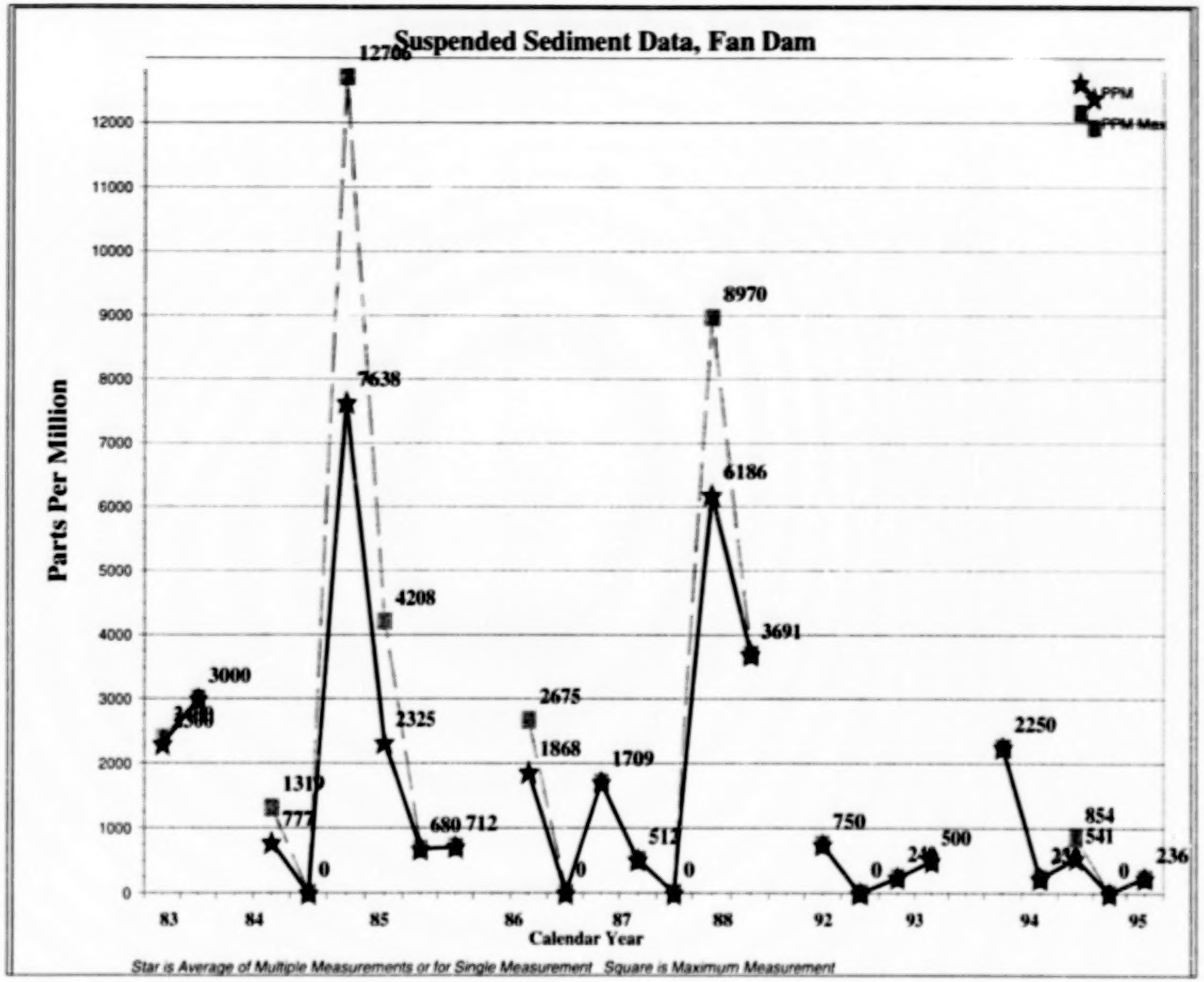
Suspended Sediment Data, Fan Dam

Table 7

Fan Dam Suspended Sediment Data

1983	**PPM, Avg.**	**No.Samples**	**PPM, Max**
10/14/83	2300	2	2400
11/10	3000		3000
1984	**PPM, Avg.**	**No.Samples**	**PPM, Max**
08/30/84	777	2	1319
1985	**PPM, Avg.**	**No.Samples**	**PPM, Max**
08/21/85	7638	2	12706
09/28	2325	2	4208
10/2	680		680
10/10	712		712
1986	**PPM, Avg.**	**No.Samples**	**PPM, Max**
08/10/86	1868	3	2675
1987	**PPM, Avg.**	**No.Samples**	**PPM, Max**
08/02/87	1709		1709
12/18	512		512
1988	**PPM, Avg.**	**No.Samples**	**PPM, Max**
08/02/88	6186	2	8970
8/17	3691		3691
1992	**PPM, Avg.**	**No.Samples**	**PPM, Max**
10/24/92	750		750
1993	**PPM, Avg.**	**No.Samples**	**PPM, Max**
01/10/93	240		240
1/19	500		500
WY1994	**PPM, Avg.**	**No.Samples**	**PPM, Max**
07/30/94	2250		2250
12/28	230		230
12/30	541	2	854
WY1995	**PPM, Avg.**	**No.Samples**	**PPM, Max**
02/22/95	236		236

Figure 12 **Suspended Sediment Data, Fan Dam**



Star is Average of Multiple Measurements or for Single Measurement Square is Maximum Measurement

Table 8 **Stormflow, Yellowhammer and Fan Dam**

SAN SIMON RIVER STREAMFLOW											
YELLOWHAMMER						FAN DAM					
DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK	DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
5/90/90	Installed					6/90/90	Installed				
6/10	Unk	1.1	Unk	Unk	Unk						
7/10	Unk	0.5	Unk	Unk	Unk						
7/17	2105	0.51		2	2120						
7/18	40	0.65		4.33	55						
7/24	Unk	0.3	Unk	Unk	Unk						
8/1	1100	0.69		2	1130						
8/13	1430	0.98		3.25	1455						
8/22	2145	0.38		0.75	2155						
8/23	100	0.43		5	155						
9/22	2215	0.91	0.54	24.5	230 9/23						
						9/24	1330	0.35	0.23	24	1730
						9/25			0.03	22.7	
						10/3	2230 10/2	0.21	0.15	24	500
						10/4		0.14	0.1	24	1300
						10/5			0.06	24	
						10/6			0.03	24	
						10/7			0.02	14.75	
02/20/91	1800	0.32	0.13	13.5	1900						
3/2	430	0.25	0.1	18.5	600						
7/22	1900	0.31	0.11	3.75	1915						
8/11	2130 8/10	2.8	0.88	24	2230 8/10						
8/12			0.1	24							
8/15	400	0.43	0.16	19	530						
						8/16	1745 8/15	0.15	0.12	24	1000
						8/17			0.1	24	
						8/18			0.07	24	
						8/19			0.04	24	
						8/20			0.03	24	
						8/21			0.02	24	
						8/22			0.02	24	
						8/23			0.01	24	
						8/31	2100 8/30	0.18	0.11	24	75 8/31
						9/1			0.05	24	
						9/2			0.02	23	
9/9	1715	2.06	0.61	24	1815						
9/10			0.07	19.75							
						9/11	1015	0.22	0.18	24	2100
9/12	2000	0.48	0.15	17.25	2200	9/12			0.1	24	
						9/13			0.08	24	
						9/14		0.18	0.12	24	900
						9/15			0.06	24	
						9/16			0.04	24	
						9/17			0.03	24	
						9/18			0.02	24	

Table 8 (Cont.) Stormflow, Yellowhammer and Fan Dam

SAN SIMON RIVER STREAMFLOW											
YELLOWHAMMER						FAN DAM					
DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK	DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
12/20/91	1500	4.05	2.56	24	200 12/21						
12/21			0.70	24		12/21	2300	1.92	1.16	24	2330
12/22			0.18	24		12/22		1.92	?	lock Stopped	
12/23			0.09	24		12/23			?		
12/24			0.02	24		12/24			?		
						12/30			?		
						01/07/92	2200	0.02	0.01	29	2300
						2/8	730	0.03	0.02	24	
						2/9			0.01	24	
04/02/92	1	0.35	0.28	24	30						
4/3			0.12	24							
4/4			0.03	24							
5/5	400	0.41	0.26	24	1630						
5/6			0.12	24							
5/7			0.04	24							
5/8			0.01	24							
5/20	1500	0.11	0.05	23	1530						
5/23	1700	0.3	0.09	30	1800						
5/29	1700	0.17	0.07	25	1715						
6/7	1230	0.97	0.23	24	1235						
6/8			0.01	8							
7/10	815	0.65	0.53	24	915						
7/11			0.21	24							
7/31	1830	0.07	0.03	16	1915						
8/9	1030	1.31	0.63	24	1045						
8/10			0.06	25		8/11	1500	0.07	0.04	27	1815
9/19	1545	0.55	0.16	27.75	1645						
10/21	45	2.45	0.92	25	345						
						10/23	130	0.08	0.05	24	600
						10/24	1630	0.54	0.54	24	100 10/25
						10/25			0.06	24	
						10/26			0.01	24	
12/4	1715	0.17	0.1	21.75	600 12/5						
01/08/93	1415	0.27	0.08	24	1515	01/08/93	400	0.03	0.02	24	745
1/9			0.02	6.25		1/9			0.01	13.5	
1/10	1920	0.48	0.14	24.5	100 1/11	1/10	1300	0.41	0.17	24	0545 1/11
						1/11		0.37	0.35	24	900 1/12
						1/12			0.23	24	
						1/13		0.26	0.16	24	1600 1/13
						1/14		0.2	0.15	24	400 1/15
						1/15			0.1	24	
						1/16			0.05	24	
1/17	120	0.26	0.1	28.5	430	1/17			0.09	24	
1/18	1140	1.37	0.6	24	2330	1/18			0.47	24	
1/19			0.32	24		1/19		1.06	0.97	24	130 1/20
1/20			0.03	10		1/20			0.9	24	
						1/21			0.3	24	
						1/22			0.06	24	
						1/23			0.04	24	
						1/24			0.03	24	
						1/25			0.02	24	

Table 8 (Cont.) **Stormflow, Yellowhammer & Fan Dam**

SAN SIMON RIVER STREAMFLOW

YELLOWHAMMER

DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
08/06/93	2000	3.9	2	22	2030
8/9	2315	0.38	0.16	15	2400
8/29	900	0.4	0.13	11	915
07/18/94	Unk	0.85	Unk	7	Unk
7/29	Unk	2.13	Unk	19	Unk
7/30	Unk	2.23	Unk	33	Unk
8/8	Unk	1.65	Unk	13.5	Unk
8/28	100	1.18	0.4	23	105
8/29	2230	0.36	0.1	9	2315
9/06	1955	0.18	0.09	7.5	1955
9/7	330	0.72	0.3	15.5	545
9/10	1900	1.84	0.27	20	1945
9/13	730	0.27	0.12	10	730
11/12	600	0.24	0.08	13.5	830
11/15			0.16	24	
12/5	1740	0.56	0.29	6	2015
12/6			0.02	24	
12/7	1720	0.65	0.52	24	2145
12/8			0.24	24	
12/9			0.05	16	
12/27	1400	0.4	0.19	10	1400
12/28		0.48	0.37	24	1400
12/29			0.2	24	
12/30			0.07	15.5	

FAN DAM

DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
7/31	1545	0.18	0.12	24	1800
8/1			0.06	24	
8/2			0.02	24	
8/9	215	0.25	0.17	24	445
8/10			0.08	24	
8/11			0.02	30	
9/13	100	0.06	0.05	23	1000
9/14			0.03	24	
9/15		0.06	0.05	24	1000
9/16			0.04	24	
9/17			0.02	19	
11/15			Unk		
11/16			Unk		
11/17			Unk		
11/18			0.04	24	
11/19			0.04	24	
11/20			0.04	24	
11/21			0.03	24	
11/22			0.03	24	
11/23			0.03	24	
11/24			0.02	24	
12/28?	Unk	0.44	Unk		Unk
12/29			Unk		
12/30		0.39	0.37	24	1530
12/31			0.25	24	

Table 8 (Cont.) **Stormflow, Yellowhammer & Fan Dam**

SAN SIMON RIVER STREAMFLOW

YELLOWHAMMER						FAN DAM					
DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK	DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
09/06/94	1955	0.18	0.09	7.5	1955						
9/7	330	0.72	0.3	15.5	545						
9/10	1900	1.84	0.27	20	1945						
9/13	730	0.27	0.12	10	730	09/13/94	100	0.06	0.05	23	1000
						9/14			0.03	24	
						9/15		0.06	0.05	24	1000
						9/16			0.04	24	
						9/17			0.02	19	
11/12	600	0.24	0.08	13.5	830						
11/14	1500	0.3	0.24	24	1700	11/14?	•	0.08	•		
11/15			0.16	24		11/15			•		
						11/16			•		
						11/17			•		
						11/18			0.04	24	
						11/19			0.04	24	
						11/20			0.04	24	
						11/21			0.03	24	
						11/22			0.03	24	
						11/23			0.03	24	
						11/24			0.02	24	
12/5	1740	0.56	0.29	6	2015						
12/6			0.02	24							
12/7	1720	0.65	0.52	24	2145						
12/8			0.24	24							
12/27	1400	0.4	0.19	10	1400						
12/28		0.48	0.37	24	1400	12/28?	•	0.44	•		•
12/29			0.2	24		12/29			•		
12/30			0.07	15.5		12/30		0.39	0.37	24	1530
						12/31			0.25	24	

Table 8 (Cont.) **Stormflow, Yellowhammer & Fan Dam**

SAN SIMON RIVER STREAMFLOW

YELLOWHAMMER

DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
01/05/95	1100	0.05	0.02	12	1145
1/7	1700	0.34	0.25	24	1930
1/8			0.07	25	
2/17	130	0.6	0.54	24	415
2/18			0.15	26	
7/17	415	0.4	UNK	UNK	UNK
8/2	15	0.28	0.08	5.75	20
8/15	300	0.23	0.1	6	315
8/16	1815	0.07	0.02	1.75	1820
8/20	1	0.42	0.19	15.5	330
8/22	1	0.63	0.26	22.5	1045
9/28	1475	0.37	0.17	3.75	1500

FAN DAM

DATE	START FLOW	PEAK	AVG DEPTH	DURAT. (HRS)	TIME OF PEAK
01/01/95			0.13	24	
1/2			0.07	24	
1/3			0.06	24	
1/4			0.07	24	
1/5		0.12	0.1	24	2200
1/6			0.13	24	
1/7		0.16	0.11	24	500
1/8			0.14	24	
1/9		0.3	0.28	24	2100
1/10			0.18	24	
1/11			0.1	24	
1/12			0.07	24	
1/13			0.06	24	
1/14			0.05	24	
1/15			0.05	24	
1/16			0.05	24	
1/17			0.04	24	
1/18			0.04	24	
1/19			0.03	24	
1/20			0.03	24	
1/21			0.03	6	
2/18	1515	0.46	0.35	9	
2/19			0.39	24	1200
2/21			0.1	24	
2/22			0.06	24	
2/23			0.05	24	
2/24			0.04	24	
2/25			0.04	24	
2/26			0.04	24	
2/27			0.03	24	
2/28			0.03	24	
2/29			0.03	17	

Table 9 was developed in answer to a question regarding the length of time for a flood to travel between the two stations. Only peak flows that could be correlated for the two stations were utilized.

The peak flow at each station establishes the starting or ending time. For each station, the date of stormflow and time of peak is given. The difference in time between occurrence of the two peaks is found in the column labeled 'Number of Hours'. The last column lists any antecedent moisture (previous stormflows past Yellowhammer station) or unusual peak flows that may have impacted the flow patterns.

A total of 16 flows were used. The shortest time for flow to travel from Yellowhammer to Fan Dam was 21.5 hours (peak flow at Yellowhammer exceeded a depth of four feet) on December 12, 1991. The longest time for peak flow to traverse the water course was 62.5 hours on January 8, 1993 (no antecedent moisture had occurred during the previous 30-days); the average number of hours from peak to peak for the 16 sets of data was 44.6 hours. The median number of hours was 49.5. Considering that the aerial distance along the water course is 8.5 miles, the average travel time for flow to move through the system varied from less than 24 hours to 2.6 days, with an overall average of nearly two days and a median of just over two days. The time required for peak flow to travel between the two stations appeared to be influenced mainly by the presence or absence of antecedent moisture over the previous 30 days.

Transects, Crosschannel

Table 10 contains the measurements of the San Simon River channel transects. The first set of stations include Sites 1 through 5, located above Barrier Dam. The five stations were surveyed in mid-1983 to determine the elevations of the streambed.

In 1989, The sites were re-surveyed. The streambed elevation at Site 1 (located four-tenths of a mile above the Barrier Dam spillway) had aggraded by 15.3 feet, the second site (eight-tenths of a mile above the spillway) had aggraded 2.3 feet and the third site (1.1 miles) by 4.3 feet. The forth site (2.46 miles) had experienced a small drop of 0.2 feet in streambed elevation but the active channel had shifted from the west side to the east side of the wide channel. The fifth site (4.1 miles) had risen 0.6 feet in elevation.

In 1995, four of the five sites were re-surveyed. The elevation of the streambed at Site 1 had risen by another 0.6 foot for a total gain of 15.9. Site 2 had gained 0.9 foot for a total of 3.2 feet. Site 3 was not measured due to the extensive growth of salt cedar along the active channel; the removal of vegetation for the one measurement would have required a days work for several people. Site 4 showed an overall loss of 0.1 foot, with the active channel shifting toward the center of the major channel. The elevation of Site 5 had risen 2.9 feet for a total gain of 3.5 feet.

Stormflow, Yellowhammer & Fan Dam

Table 9

Time Difference in Streamflow, Yellowhammer to Fan Dam					
Yellowhammer Station		Fan Dam Station			Yellowhammer Last
Date	Time of Peak	Date	Time of Peak	No. of Hours	Streamflow Dates
09/23/90	230	09/24/90	1730	39	8/13, 8/22, 8/23
08/15/91	530	08/16/91	1000	28.5	8/11, 8/12
09/09/91	1815	09/11/91	2100	50.75	8/11, 8/12, 8/15
09/12/91	2200	09/14/91	900	35	9/9 & 10
12/21/91	200	12/21/91	2330	21.5	4.05 foot Peak Flow
08/09/92	1045	08/11/92	1815	55.5	7/31
10/21/92	345	10/23/92	600	50.25	9/19 & 2.45 ft Peak Flow
01/08/93	1515	01/11/93	545	62.5	12/4
01/11/93	100	01/12/93	900	36	1/8
01/18/93	2330	01/20/93	130	26	1/10, 1/17
09/10/93	1945	09/13/93	1000	62.25	8/28, 8/29, 9/6, 9/7
09/13/93	730	09/15/93	1000	50.5	9/6, 9/7, 9/10
12/28/94	1400	12/30/94	1530	49.5	12/5, 12/7, 12/27
01/05/95	1145	01/07/95	500	41.25	12/27 - 30
01/07/95	1145	01/09/95	2100	49.5	1/5
02/17/95	415	02/19/95	1200	55.75	1/7 - 8
			Average	44.61	

Table 10 San Simon River Channel Transects

Crosschannel Transects on San Simon River

(Channel Elevation and Gain/Loss in Feet)

Station	**No. 1 (Powerline)**		**No. 2**		**No. 3**		**No. 4**		**No. 5**	
Date	Chan. Elev.	Gain/Loss	Chan. Elev.	Gain/Loss	Chan. Elev.	Gain/Loss	Chan. Elev.	Gain/Loss	Chan. Elev.	Gain/Loss
1983	3004.4		3019.9		3021.2		3060		3065.1	
1989	3019.7	15.3	3022.2	2.3	3025.5	4.3	3059.8	0.2	3065.7	0.6
1995	3020.3	15.9	302301	3.2	No Measurement		3059.9	0.1	3068.6	3.5

Station	**Bailey Well**			**Yellowhammer North**			**Yellowhammer South**		
Date	Chan. Elev.	Gain/Loss	Chan. Width	Chan. Elev.	Gain/Loss	Chan. Width	Chan. Elev.	Gain/Loss	Chan. Width
10/89	3245.6		46	3483.75		76	3489.35		81
2/92	3246.1	0.5	48 (+2)	No Measurement			3489.5	0.15	85 (+4)
6/95	3246.45	0.85	45 (-3)	3484.87	1.12	67 (-9)	3489.85	0.5	79 (-6)

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In the Bailey Well Sediment Data section, it was suggested that there may have been an increase in quantities of sediment moving through the stream system during the 1990's. The only transect data that may account for this additional sediment is the substantial gain noted at Transect 5, since the other transect lines had either no gain or only modest gains. Therefore, the only reasonable explanation for the extraordinary peaks would be that very local, short-duration, high-intensity storms had occurred on one or more tributaries immediately above Bailey Well, flushing the sediment past the station and depositing it further downstream.

In late-1989, Bailey Well, Yellowhammer North and Yellowhammer South sites were surveyed to establish channel elevations. In early 1992 the re-survey of Bailey Well showed a net gain of 0.50 foot, but the channel was two feet wider than it had been in 1989. Yellowhammer North was not measured in 1992. Yellowhammer South had acquired 0.15 foot of sediment and the channel had increased in width by four feet.

In 1995, the Bailey Well channel had risen another 0.35 feet, with the channel narrowing by a total of three feet. Yellowhammer North had gained 1.12 feet of elevation and a decrease in width of nine feet across the channel. Yellowhammer South had also risen 0.35 feet and decreased six feet in width. All measurements are based on thalweg elevations (line joining deepest points in a stream channel, as measured from known elevations).

Electrical Conductivity, San Simon River

In 1990, the question was raised on how much salinity was escaping from the watershed during stormflow. Starting in September of that year, the Electrical Conductivity (EC) was measured in the laboratory prior to the preparation of each sediment in order to ascertain the amount of free salt ions in the given solution. The units were measured in micromhos, abbreviated Mmhos

Table 11 outlines the EC of sediment-in-solution samples collected at Barrier Dam. The table gives the maximum and minimum measurements for each set of samples and the stage for each at time of collection. When two or more samples exist within a set, the average is listed in the sixth column and the corresponding maximum stage and number of samples in each set are given in column seven and eight. The number of samples for a single period of flow varied from one to 38.

Figure 13 is a plot of the EC data taken from Table 11. Early in the data collection there were a number of peak readings: such as the 2310 Mmhos/cm in July 1991. In the first 2.5 years (through 1992) eight measurements exceeded 1000 Mmhos/cm, while during the final 2.5 there were only two peaks that exceeded 1000 Mmhos/cm. Although, 1992 was the wettest period during this portion of the study, only three of the eight peaks occurred during that year.

Measurements in the first 2.5 years fluctuated up and down, failing

Electrical Conductivity, San Simon River Table 11

Electrical Conductivity Data Barrier Dam 1990 - 1995							
Date	Max EC	Stage	Min EC	Stage	Avg. EC	Max Stage	# Samp.
9/4-5/90	1520	0.33	524	0.12	854	0.33	11
9/22	1182	0.35			1182	0.35	1
10/2-3	560	0.19	460	0.14	506	0.19	6
11/8	633	0.19	542	0.15	589	0.19	5
7/30-31/91	2310	0.25	520	0.25	957	0.25	5
8/8-9	1628	0.28	493	0.07	857	0.28	7
8/10	361	0.13	355	0.11	358	0.13	3
8/14-16	634	0.28	363	0.13	482	0.28	9
8/26-28	736	0.28	396	0.1	572	0.28	7
9/5-6	448	0.25	301	0.13	346	0.25	9
9/12	526	?			526	?	1
9/27	353	0.15	305	0.1	338	0.15	5
12/11	1051	0.04	1037	0.04	1043	0.04	4
12/20-24	479	0.07	222	0.5+	276	0.07	38
02/14/92	351	0.11	331	0.12	342	0.11	4
4/2-3	1460	0.1	684	0.09	802	0.18	13
5/19	1355	0.22	897	0.14	1089	0.22	3
8/6-7	861	0.16	685	0.09	746	0.16	3
8/21	702	0.17	408	0.15	555	0.17	2
8/24	685	0.32	350	0.26	461	0.32	30
9/20	1048	0.14			1048	0.14	1
01/08/93	1346	0.08	819	0.12	1085	0.16	6
1/11	585	0.14	425	0.14	495	0.14	5
1/12	366	0.18	295	0.19	324	0.18	8
1/13	676	0.19	316	0.16	443	0.19	7
1/14-15	339	0.14	323	0.15	333	0.14	6
1/19	346	0.22			346	0.22	1
1/20	305	0.21	254	0.22	274	0.24	12
1/21	328	0.23	284	0.23	308	0.23	6
8/17	458	0.06	416	0.06	437	0.06	2
8/27-28	751	0.14	525	0.14	638	0.14	2
8/31	421	0.18	298	0.72	372	0.95	15
9/1	677	0.15	447	0.25	561	0.15	7
7/28-29/94	931	0.17	621	0.08	732	0.17	3
7/30	734	0.17			734	0.17	1
8/8	596	0.17	333	0.15	370	0.19	10
8/10	453	0.11	449	0.11	451	0.11	2
8/31	464	0.12	463	0.12	463	0.12	2
9/3	1299	0.15	536	0.17	764	0.22	8
9/12	791	0.18			791	0.18	1
9/13	484	0.09	476	0.09	480	0.09	2
11/14	489	0.08			489	0.08	1
12/6	585	0.18	499	0.18	542	0.19	4
12/7	523	0.1			523	0.1	1
12/27	819	0.13	723	0.13	784	0.13	3
12/29	551	0.03			551	0.03	1
01/05/95	839	0.17	481	0.2	578	0.21	11
1/6	490	0.14	462	0.17	479	0.19	6
2/16	591	0.11	492	0.11	532	0.11	3
2/17	587	0.07			587	0.07	1
2/22	602	0.1			602	0.1	1
2/23	610	0.22	531	0.19	569	0.22	5
9/28-29	910	0.11	520	0.08	793	0.11	5

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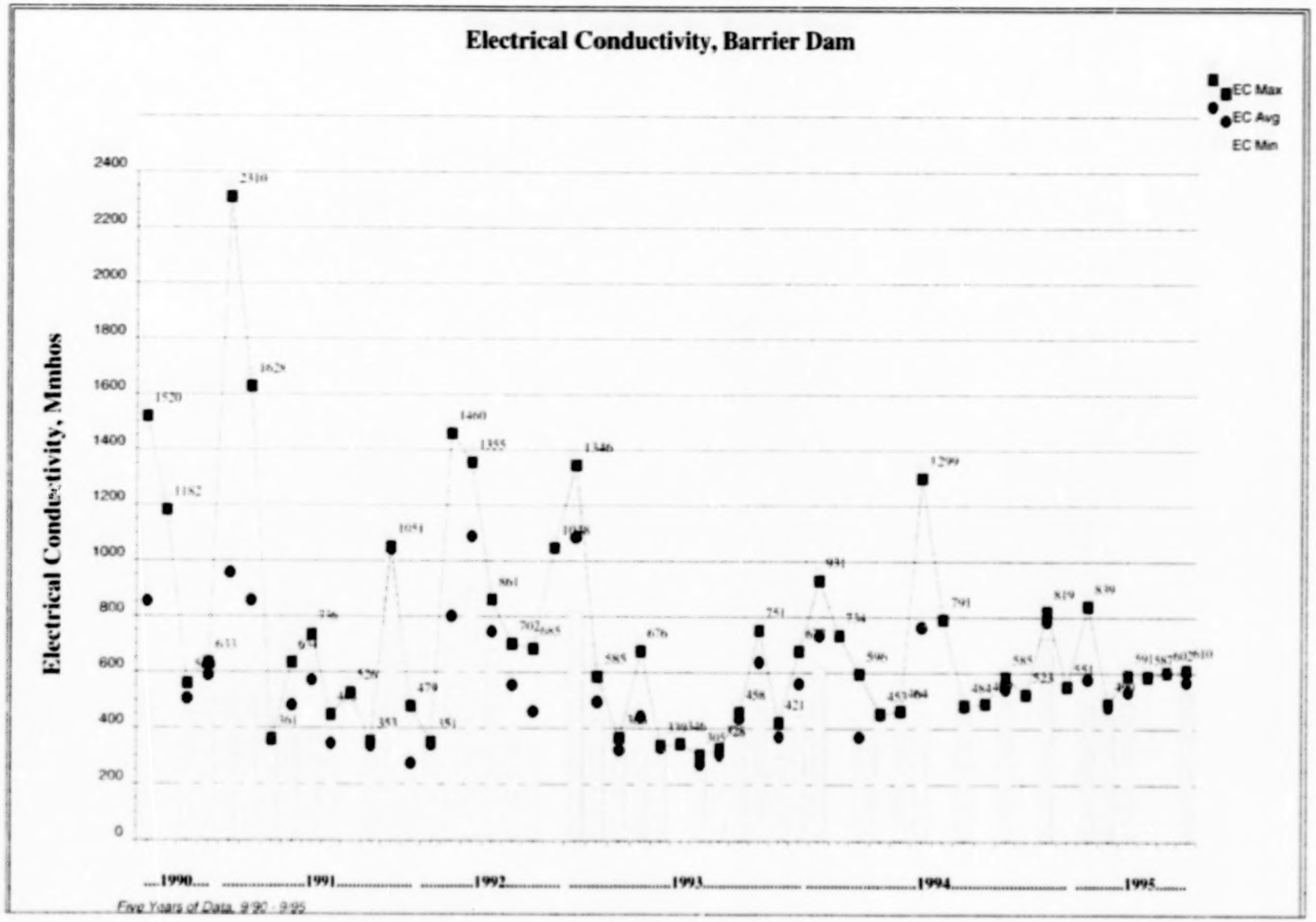
Figure 13 **Electrical Conductivity, San Simon River**



to settle at one level. The second 2.5 years appeared to settle somewhat in 1993, showing a gradual increase to the end of the study (see Figure 13). What this means is uncertain.

Table 12 contains the salinity data collected at Bailey Well and Figure 14 displays the plotted data. No trend is apparent. While a number of measurements exceeded 1000 Mmhos at the Barrier Dam, only one measurement at Bailey Well approached that mark: 983 Mmhos on July 24, 1991. The second highest measurement was 710 on February 13, 1992 and the overall average was 371 Mmhos.

Table 13 shows the seven EC measurements of sediment samples from stormflow through Fan Dam. Only two samples were captured during the same flow period. The highest EC was 378 Mmhos on December 30, 1994 and the average of the seven samples was 312 Mmhos. The plot of this data can be seen in Figure 16.

The single and multiple measurements from Barrier Dam, Bailey Well and Fan Dam were used to determine whether a correlation exists between the sites. The data for specific storm events were used only where a comparison could be inferred. Table 14 contains the data and Figure 15 shows the relationships that exist among the three sites. The chart shows that the river system below Bailey Well produces more salts than the system above Bailey Well. The quantity of salts passing through Fan Dam is consistently low and relatively steady. The existing dam structure and the resultant vegetative growth may be responsible for restricting the passage of salts down the river. Across the West, the usual methods for controlling movement of salts are the construction of confining dam structures and the improvement in vegetative cover.

Table 15 and Figure 16 were developed using only the maximum measurements within the specific time frames. In several cases, the data given for the Barrier Dam does not represent the maximum measurement from the start of the storm, but rather the largest measurement captured during the storm event. As a result, this data is ambiguous considering the time frame required for stormflow to travel between Yellowhammer and Fan Dam. A straight-line distance between Fan Dam and Barrier Dam is approximately 21 miles.

Figure 16 has been included to illustrate the placement of the three sets of data in relation to one another. As stated earlier, larger quantities of salts flow through Barrier Dam than within the rest of the river system.

Overall, the quantity of salts leaving the watershed at Barrier Dam is fairly small. Table 16 (five pages) displays all the flow days and salinity data by calendar year, except the 1990 and 1991 data which was combined. The data box at the bottom of the fifth page of Table 16 shows the average ppm's of salt for each year and the computed tons of salts exiting the watershed. The average of all data was 491 Mmhos/cm, which computes to 314 ppm (1000 Mmhos/cm approximately equals 640 parts per million of salts). This amount of salts can usually be found in normal drinking water in southeast

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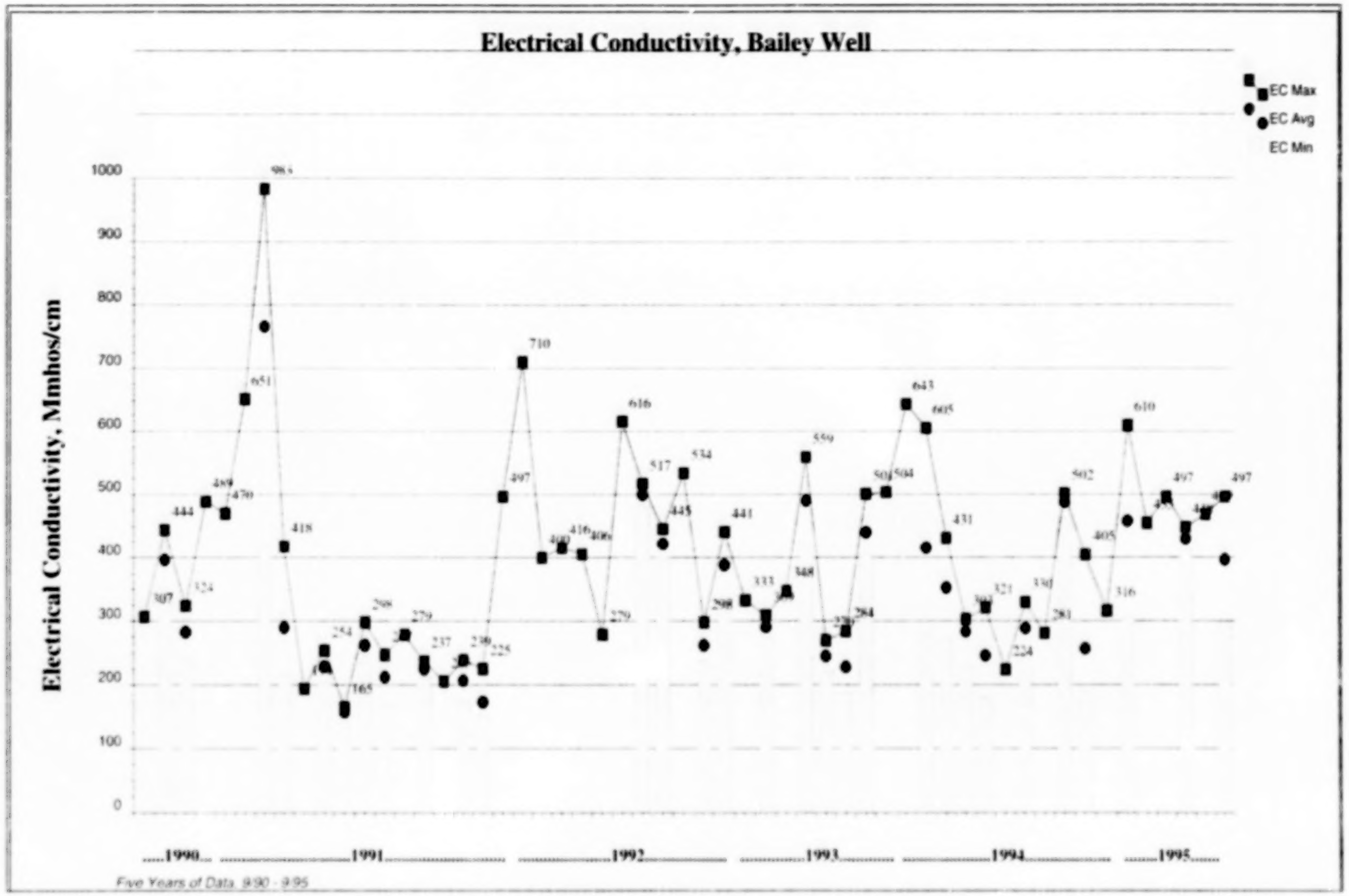
Electrical Conductivity, San Simon River

Table 12

Bailey Well	Electrical Conductivity 1990 -1995			
Date	Max EC	Min EC	Avg. EC	#of Samples
09/22/90	307		307	1
9/30	444	351	397	2
11/7	324	243	283	2
12/16	489		489	1
02/13/91	470		470	1
7/10	651		651	1
7/24	983	420	766	3
7/30	418	216	290	4
8/8	194		194	1
8/9	254	204	229	2
8/14	165	152	158	2
8/26	298	237	262	3
9/5	247	170	212	3
9/6	279		279	1
9/12	237	213	225	3
11/16	205		205	1
12/11	239	176	207	2
12/20	225	152	173	4
02/02/92	497		497	1
2/13	710		710	1
3/4	400		400	1
3/27	416		416	1
4/2	406		406	1
5/5	279		279	1
5/19	616		616	1
8/6	517	483	500	2
8/21	445	400	422	2
8/23	534		534	1
8/26	298	237	262	3
9/20	441	338	389	2
02/20/93	333		333	1
7/12	309	275	291	2
7/21	348		348	1
8/7	559	423	490	2
8/27	270	220	245	2
8/31	284	188	228	3
10/6-7	501	407	440	4
11/15	504		504	1
03/15/94	643		643	1
6/22	605	279	416	5
7/24	431	272	353	5
7/30	303	231	284	4
8/8	321	179	246	5
8/31	224		224	1
9/3	330	249	289	2
9/12	281		281	1
11/13	502	463	488	2
12/5	405	190	257	3
12/26	316		316	1
01/04/95	610	306	458	2
2/16	455		455	1
8/23	497		497	1
8/28	448	413	430	2
8/30	469		469	1
9/28	497	297	397	2

Figure 14 **Electrical Conductivity, San Simon River**



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Electrical Conductivity, San Simon River

Table 13

Fan Dam Electrical Conductivity				
Date	Max EC	Min EC	Avg. EC	# of Samp.
10/24/92	340			1
01/10/93	245			1
1/19	246			1
07/30/94	243			1
12/30	378	375	376	2
2/22	356			1

Electrical Conductivity, San Simon Watershed Table 14

Barrier Dam, Bailey Well & Fan Dam				
Correlation of EC for Specific Storm Events, Multiple Meas.				
Date		Bailey	Barrier	Fan
09/22/90	1	307	1182	
9/30-10/2	2	397	506	
11/7-8	3	283	589	
7/30	4	290	957	
8/9	5	229	857	
8/14-16	6	158	482	
8/26-28	7	262	572	
9/5-6	8	212	346	
9/12	9	225	526	
12/11	10	207	1043	
12/20	11	173	276	
2/13-14/92	12	710	479	
4/2-3	13	406	802	
5/19	14	616	1089	
8/6	16	500	746	
8/21	17	422	555	
8/26-28	18	262	572	
9/20	19	395	1048	
1/10-12/93	20		496	245
1/19-21	21		308	246
8/27-28	22	245	638	
8/31	23	227	371	
07/30/94	24	303	734	243
8/8	25	246	370	
8/31	26	284	463	
9/3	27	330	764	
9/12	28	281	790	
11/13	29	488	498	
12/5-6	30	257	542	
12/26-27	31	315	784	
1/4-5/95	32	458	578	378
2/16	33	455	532	
2/22-23	34		569	356
9/28	35	397	861	

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Figure 15 **Electrical Conductivity, San Simon Watershed**

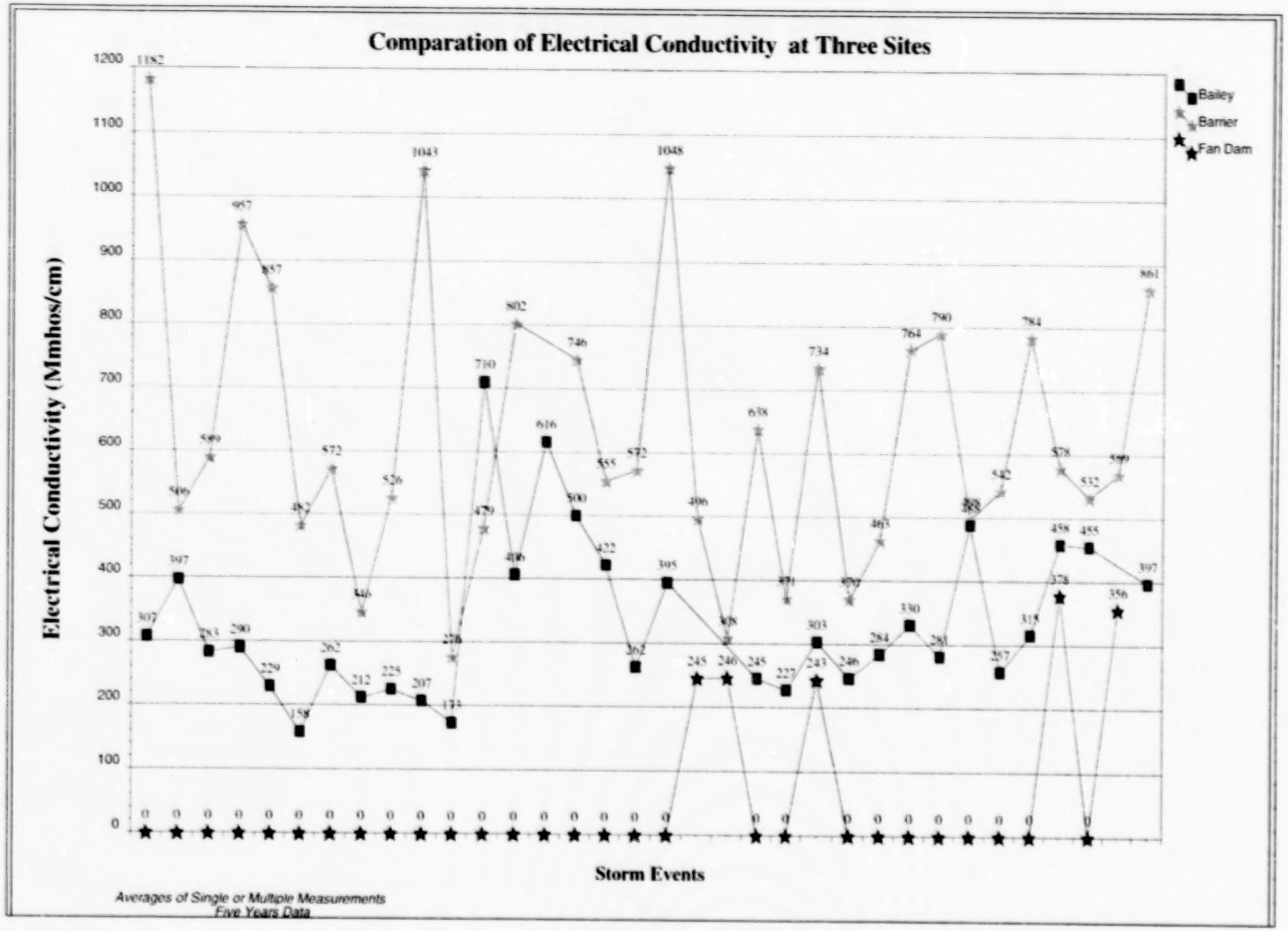
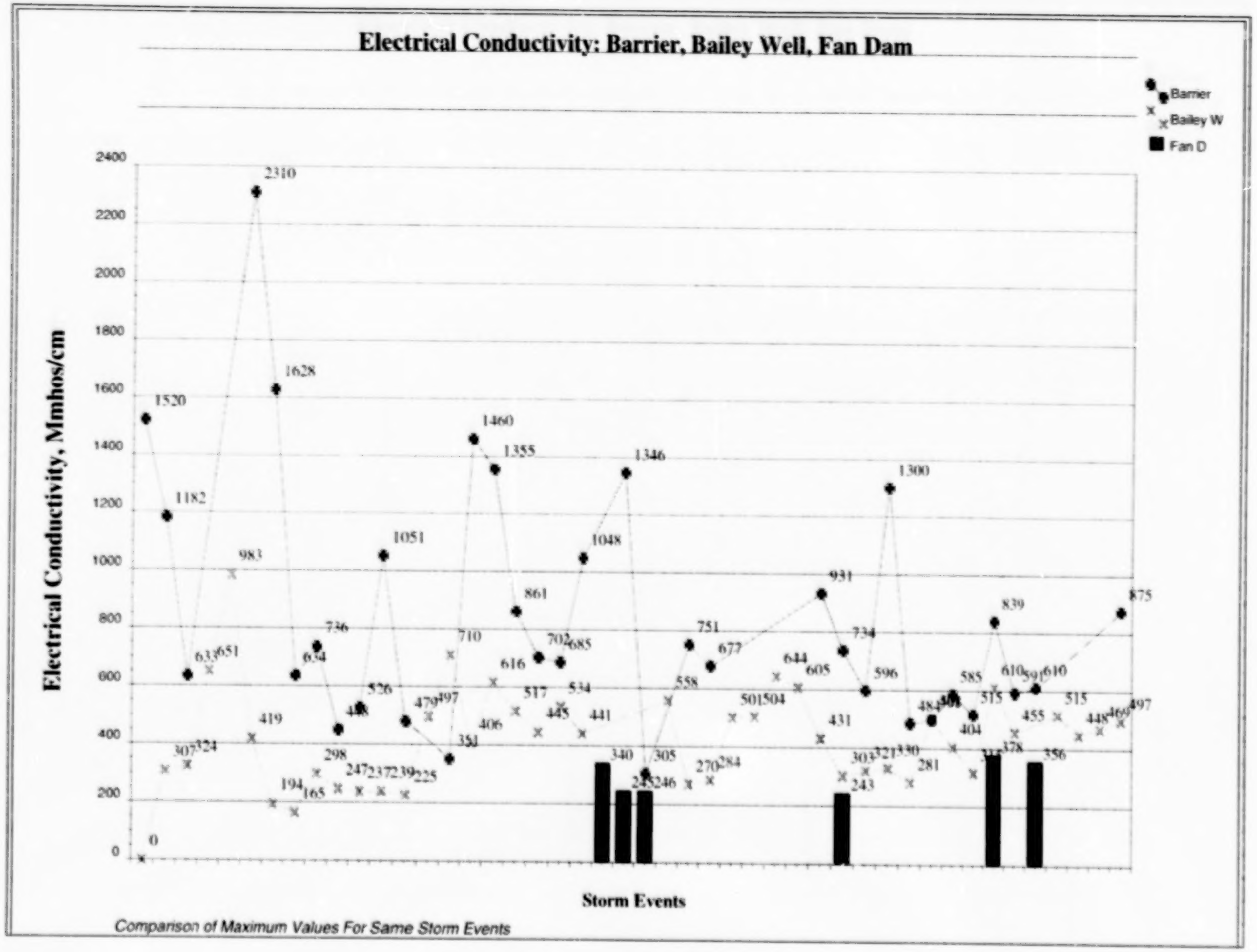


Figure 16 **Electrical Conductivity, San Simon Watershed**



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Measurement of Salts, San Simon River

Table 16

Computed Tons of Salts		Barrier Dam 9/90 to12/91			
Date	EC mmhos	EC ppm	Ratio of Sal	Sedim. Tons	Tons Salt
9/4-5/90	854	547	0.0005466	3823.9	2.0900
9/6	380	243	0.0002432	5.7	0.0014
9/22-23	725	464	0.000464	6323.4	2.9341
9/24	360	230	0.0002304	205.8	0.0474
10/1	510	326	0.0003264	7891.9	2.5759
10/2	460	294	0.0002944	1697.0	0.4996
10/3	325	208	0.000208	34.3	0.0071
11/7	605	387	0.0003872	11185.5	4.3310
11/8	495	317	0.0003168	683.0	0.2164
12/16	825	528	0.000528	4042.1	2.1342
12/17	390	250	0.0002496	31.6	0.0079
12/18	285	182	0.0001824	1.4	0.0003
12/28	780	499	0.0004992	6857.2	3.4231
12/29	495	317	0.0003168	2309.8	0.7317
12/30	320	205	0.0002048	142.7	0.0292
12/31	260	166	0.0001664	0.4	0.0001
02/14/91	390	250	0.0002496	50.7	0.0127
2/18	440	282	0.0002816	765.4	0.2155
3/2	365	234	0.0002336	299.9	0.0701
7/30	1220	781	0.0007808	3779.5	2.9510
7/31	505	323	0.0003232	701.5	0.2267
8/8-9	923	591	0.0005907	8493.2	5.0171
8/10	355	227	0.0002272	2090.4	0.4749
8/11	315	202	0.0002016	766.5	0.1545
8/12	290	186	0.0001856	64.8	0.0120
8/14-15	600	384	0.000384	13021.2	5.0001
8/16	470	301	0.0003008	2104.6	0.6331
8/27	540	346	0.0003456	3525.5	1.2184
8/28	455	291	0.0002912	1411.6	0.4111
9/5	346	221	0.0002214	3078.9	0.6818
9/6	301	193	0.0001926	1897.3	0.3655
9/12	480	307	0.0003072	931.2	0.2861
9/27	338	216	0.0002163	731.5	0.1582
12/11	1043	668	0.0006675	7.1	0.0047
12/18	555	355	0.0003552	175.1	0.0622
12/19	510	326	0.0003264	486.7	0.1589
12/20	443	284	0.0002835	25129.3	7.1247
12/21	350	224	0.000224	10681.6	2.3927
12/22	276	177	0.0001766	8928.9	1.5772
12/23	264	169	0.0001690	6396.3	1.0807
12/24	240	154	0.0001536	1155.0	0.1774
12/25	225	144	0.000144	686.3	0.0988
12/26	221	141	0.0001414	288.4	0.0408
Avg/Total		**306**			**49.64**
1/91 to 12/91		295			30.61

Measurement of Salts, San Simon River Table 16 (Cont.)

Computed Tons of Salts		Barrier Dam 1/92 to 12/92			
Date	EC mmhos	EC ppm	Ratio of Sal	Sedim. Tons	Tons Salt
02/13/92	365	234	0.0002336	4961.1	1.1589
2/14	342	219	0.0002189	133.5	0.0292
3/28	482	308	0.0003085	1646.3	0.5079
3/29	294	188	0.0001882	487.7	0.0918
4/2	1208	773	0.0007731	7568.9	5.8517
4/3	802	513	0.0005133	1031.1	0.5292
4/4	651	417	0.0004166	295.0	0.1229
4/5	312	200	0.0001997	29.9	0.0060
4/6	234	150	0.0001498	3.2	0.0005
5/4	396	253	0.0002534	44.4	0.0113
5/5	423	271	0.0002707	544.0	0.1473
5/6	231	148	0.0001478	12.7	0.0019
5/8	389	249	0.0002490	1118.3	0.2784
5/10	378	242	0.0002419	746.6	0.1806
5/19	1089	697	0.0006970	1032.3	0.7195
5/20	619	396	0.0003962	2864.6	1.1348
5/21	299	191	0.0001914	30.5	0.0058
5/30	318	204	0.0002035	57.0	0.0116
6/8	422	270	0.0002701	17.1	0.0046
7/11	774	495	0.0004954	6601.3	3.2700
7/12	293	188	0.0001875	141.7	0.0266
8/6-7	852	545	0.0005453	4462.5	2.4333
8/12	338	216	0.0002163	5.3	0.0011
8/21	555	355	0.0003552	2714.3	0.9641
8/22	408	261	0.0002611	1411.1	0.3685
8/23	540	346	0.0003456	12407.3	4.2880
8/24	461	295	0.0002950	5651.9	1.6675
8/25	506	324	0.0003238	6.0	0.0019
9/20	1020	653	0.0006528	2656.3	1.7340
12/4	432	276	0.0002765	4.3	0.0012
12/7	256	164	0.0001638	5.2	0.0009
12/8	368	236	0.0002355	449.8	0.1059
12/9	351	225	0.0002246	319.5	0.0718
12/10	221	141	0.0001414	3.1	0.0004
12/29	588	376	0.0003763	1099.2	0.4137
12/30	311	199	0.0001990	160.4	0.0319
12/31	233	149	0.0001491	3.1	0.0005
Avg/Total		**307**			**26.18**

Measurement of Salts, San Simon River Table 16 (Cont.)

Computed Tons of Salts		Barrier Dam 1/93 to 12/93			
Date	EC mmhos	EC ppm	Ratio of Sal	Sedim. Tons	Tons Salt
01/08/93	1085	694	0.0006944	4703.7	3.2662
1/9	819	524	0.0005242	862.9	0.4523
1/10	665	426	0.0004256	946.9	0.4030
1/11	495	317	0.0003168	3231.6	1.0238
1/12	324	207	0.0002074	4437.6	0.9202
1/13	443	284	0.0002835	7263.1	2.0592
1/14	333	213	0.0002131	1887.9	0.4023
1/15	323	207	0.0002067	323.5	0.0669
1/16	301	193	0.0001926	0.9	0.0002
1/19	346	221	0.0002214	4062.8	0.8997
1/20	274	175	0.0001754	5954.6	1.0442
1/21	308	197	0.0001971	4396.6	0.8667
1/22	296	189	0.0001894	750.9	0.1423
1/23	255	163	0.0001632	125.7	0.0205
2/20	515	330	0.0003296	19.8	0.0065
7/12	622	398	0.0003981	26.8	0.0107
7/14	423	271	0.0002707	1464.5	0.3965
7/16	436	279	0.0002790	420.2	0.1173
8/3	456	292	0.0002918	318.9	0.0931
8/7	489	313	0.0003130	4336.3	1.3571
8/8	410	262	0.0002624	44.4	0.0117
8/10	398	255	0.0002547	1.3	0.0003
8/14	429	275	0.0002746	3.8	0.0010
8/16	458	293	0.0002931	3.7	0.0011
8/17	437	280	0.0002797	25.6	0.0072
8/28	638	408	0.0004083	2236.7	0.9133
8/31	372	238	0.0002381	22052.2	5.2502
9/1	562	360	0.0003597	886.2	0.3187
9/2	440	282	0.0002816	28.2	0.0079
9/3	352	225	0.0002253	1.5	0.0003
10/7	643	412	0.0004115	4884.8	2.0102
10/8	410	262	0.0002624	440.1	0.1155
11/15	456	292	0.0002918	2552.2	0.7448
Avg/Total		**295**			**22.93**

Measurement of Salts, San Simon River Table 16 (Cont.)

Computed Tons of Salts Barrier Dam 1/94 to 12/94					
Date	EC mmhos	EC ppm	Ratio of Sal	Sedim. Tons	Tons Salt
03/20/94	488	312	0.0003123	307.8	0.0961
6/22	779	499	0.0004986	2517.3	1.2550
7/25	496	317	0.0003174	95.9	0.0304
7/29	732	468	0.0004685	2099.1	0.9834
7/30	621	397	0.0003974	3650.5	1.4509
7/31	321	205	0.0002054	29.1	0.0060
8/5	689	441	0.0004410	1085.4	0.4786
8/6	431	276	0.0002758	10.4	0.0029
8/8	370	237	0.0002368	5684.5	1.3461
8/9	320	205	0.0002048	7374.1	1.5102
8/10	451	289	0.0002886	836.5	0.2414
8/11	425	272	0.000272	2.3	0.0006
8/31	566	362	0.0003622	7.2	0.0026
9/3	764	489	0.0004890	6420.8	3.1395
9/4	536	343	0.0003430	1775.0	0.6089
9/5	421	269	0.0002694	25.3	0.0068
9/6	342	219	0.0002189	0.8	0.0002
9/11	863	552	0.0005523	3823.3	2.1117
9/12	791	506	0.0005062	1899.7	0.9617
9/13	436	279	0.0002790	18.1	0.0051
11/12	799	511	0.0005114	17001.0	8.6936
11/13	587	376	0.0003757	5031.4	1.8902
11/14	475	304	0.000304	86.8	0.0264
12/6	542	347	0.0003469	10550.6	3.6598
12/7	499	319	0.0003194	569.9	0.1820
12/8	466	298	0.0002982	7.6	0.0023
12/27	784	502	0.0005018	4552.2	2.2841
12/28	665	426	0.0004256	1139.9	0.4851
12/29	550	352	0.000352	7.6	0.0027
Avg/Total		**358**			**31.46**

Measurement of Salts, San Simon River Table 16 (Cont.)

Computed Tons of Salts		Barrier Dam 1/95 to 12/95			
Date	EC mmhos	EC ppm	Ratio of Sal	Sedim. Tons	Tons Salt
01/02/95	839	537	0.0005370	50.5	0.0271
1/3	621	397	0.0003974	1.3	0.0005
1/5	578	370	0.0003699	11623.4	4.2997
1/6	479	307	0.0003066	5973.2	1.8311
1/7	452	289	0.0002893	1519.8	0.4396
1/8	356	228	0.0002278	244.9	0.0558
1/9	310	198	0.0001984	25.3	0.0050
1/10	290	186	0.0001856	7.6	0.0014
1/11	279	179	0.0001786	1.7	0.0003
1/12	271	173	0.0001734	1.7	0.0003
1/13	261	167	0.0001670	0.2	0.0000
2/16	532	340	0.0003405	2378.3	0.8098
2/17	580	371	0.0003712	7.6	0.0028
2/22	602	385	0.0003853	2507.7	0.9662
2/23	521	333	0.0003334	1699.1	0.5665
2/24	399	255	0.0002554	7.6	0.0019
8/18	486	311	0.0003110	3.6	0.0011
8/19	321	205	0.0002054	6.0	0.0012
8/22	498	319	0.0003187	14.6	0.0047
8/23	531	340	0.0003398	440.9	0.1498
8/28	484	310	0.0003098	707.9	0.2193
9/1	433	277	0.0002771	19.6	0.0054
9/11	524	335	0.0003354	245.8	0.0824
9/28	793	508	0.0005075	5586.9	2.8355
9/29	520	333	0.0003328	96.2	0.0320
Avg/Total		**305**			**12.34**
	Dates	PPM Avg	Tons of Salt		
	9/90 to 12/91	306	49.64		
	1/92 to 12/92	307	26.18		
	1/93 to 12/93	295	22.93		
	1/94 to 12/94	358	31.46		
	1/95 to12/95	305	12.34		
	Avg/Total	314	142.55		

Arizona.

For the 5.5-year period of data collection, a total of 142.55 tons of salts left the watershed. A 1991 District memorandum to the Arizona State Director, regarding a report to Congress on salinity in the Colorado River System, stated that the alluvial soil of the San Simon watershed generally ranged between 0.1 to 0.5 percent salt, excluding 24,000 acres of extremely saline soils. In this report, the diluted salts, as measured at Barrier Detention Dam, averaged 0.03 percent.

Conclusions

The pieces of data has been presented, and it can be argued that one piece of data is inconclusive, or another segment of data fails to confirm that improvement is occurring. But, all of the data taken together presents a larger picture that indicates the overall stream channel, it's associated riparian areas, and some the upland watershed are improving with an upward trend:

A. Streamflow Data

1. The graph of the yearly stormflow displays the peaks and valleys of the annual flows, with the fluctuations descending erratically from the first data point. In the tenth year of the study (1992), an average of 16.26 inches of precipitation occurred, which was the second highest measurement during the study. However, the resulting flow was smaller than any of the previous flows, except for 1988, which had 4.21 inches less precipitation. The January 1993 flood occurred throughout the Southwest, but the San Simon River failed to reach or even approach flood stage. It is obvious that the increased precipitation had no affect on the respective runoff or on the sediment yield, which will be discussed later. The computation and plotting of the running averages in Figure 4A clearly show the reduction in flows leaving the watershed. It would seem reasonable, then, to assume that if less runoff is occurring, more water is staying in place on the watershed to encourage vegetative growth. One may then conclude that the stream channel and portions of the upland watershed are actively healing and restoring themselves.

B. Flow Days at Barrier Dam

1. The number of flow days occurring per calendar year decreased as the project progressed. In the ninth year (1992), there were a total of 37 days, while the sixth year (1988) produced 43 days with 4.58 inches less precipitation.

C. Sediment Data, Barrier Dam

1. Figure 6 shows the plotted sediment yield, which is quite similar in appearance to Figure 4 (stormflow), leading to a similar conclusion. The sediment yield was not affected by an increase in precipitation in 1992. In fact, the tenth year produced less

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sediment than eight of the nine previous years. The plot of the running averages for this data (Figure 6A) also defines a continuous decrease in suspended sediments leaving the watershed. With water staying on the watershed and the numerous erosion control structures in place, the movement of sediment will generally occur only after high-intensity or long-duration storms.

2. By dividing precipitation into sediment yield, a ratio was computed and plotted, as seen in Figure 8. This graph is similar to both Figures 4 and 7, but the last five years reveal a definite decline in sediment production with respect to the variation in quantities of precipitation.

D. Sediment Data, Bailey Well and Fan Dam

1. Except for a few outliers (anomaly) in the Bailey Well sediment graph, in Figure 9, the plotted data appears to be relatively uniform. The measurements tend to fluctuate around the 50,000 ppm's for the entire study. Intensity and proximity of storms were probably the driving forces behind the severe fluctuations that can be observed in the plots. Figure 12, the Fan Dam data, indicates that the low sediment yield appears to be decreasing over time.

E. Cross-channel Transects

1. During the study, a total of eight cross-channel transects on the main channel were established, surveyed and measured; five above Barrier Dam, a later one at Bailey Well, and two near Yellowhammer Well. The second transect measurements above Barrier Dam revealed that at all sites except one, the channel streambed was aggrading. The second measurements at Yellowhammer and Bailey Well sites, 1992, found that the streambanks had widened. The 1995 measurements indicated that all sites continued to aggrade, while the streambanks at Yellowhammer and Bailey Well had significantly narrowed.

From this preponderance of data, one can conclude that the stream channel and the watershed are presently in the slow processes of restoration. The marked decline in stormflow, number of flow days, and sediment yield noted during this study are positive indications of the effects of the restoration projects and management programs that have significantly reduced or controlled erosion within the watershed. These projects included the construction of detention dams, the implementation of range management practices (including reduction of cattle numbers, fencing of riparian areas, construction of numerous rock masonry dams, and installation of dependable waters to disperse livestock and wildlife), the installation of concrete drive-throughs (river fords), a half-dozen grass seedings totaling 15,000 acres in the 1970's, and possibly the residual effects from the Civilian Conservation Corp erosion control structures of the 1930's.

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Recommendations

The Resource Area must continue to promote and implement good management practices in the watershed, with particular emphasis given to the Fan Dam and Contest Well areas.

Continue to encourage and reward good resource management by ranchers and publicize their work as outstanding examples of effective land management.

Work with ranchers that graze public lands requiring additional improvement or reclamation. Suggest best management practices or encourage them to implement their own best management practices.

Continue to work with groups outside the BLM and encourage employee and Field Office participation in groups, such as Multi-Multi "Gila Monster" Interstate Watershed Management Program and San Carlos/Safford/Duncan Non-point Source Management Zone Group. Prepare a cooperative watershed demonstration project with the two entities that dovetails with their respective programs.

Continue to maintain the three streamgaging stations within the San Simon watershed in order to monitor the occurrence, frequency and duration of stormflow events, and evaluate the effectiveness of the monitoring every two years starting in 1998.

If additional recording raingages can be acquired, they should be installed in following locations: 1. the west edge of Peloncillo Wilderness Area, north of the Orange Butte area. 2. Replace the raingage at Ash Peak.

Many detention dams within the San Simon watershed have met or exceeded expectations. Barrier and Fan Dams have caused the up-stream channel to aggrade for a number of miles, and Goat Well Dam on Slick Rock Wash, has been very successful. Therefore, even in these austere times, the Bureau must continue to seek congressional funding for dam construction. The majority of the detention structures are located along the east side of the watershed. Except for HX and Gold Gulch dams, there are no major structures along the west side. Instead of constructing Timber Draw Detention Dam, which would be located on the San Simon channel, construct a at least three smaller dams along the west side. Three drainages that could be considered are Oak Draw, Willow Springs Wash and Timber Draw. Archeological mitigation on these smaller drainages would be minimal, and the combined costs of the dams would be less than the total cost of constructing the originally proposed dam. Erosion control would be more effective if sediment were retained within each respective drainage, rather than damming it in the main channel. Only Timber Draw flows into the originally proposed site, while the other drainages enter The San Simon River below the site. The combined acreage of the three watersheds is approximately 35,000.

Abandon those detention structures that have not proven effective.

Appendix A

Water Level Recorder Station, Barrier Dam
The housing, constructed of steel-plate, was mounted on an inverted 24-inch ID, twelve foot long culvert, which served as a stilling well. The well was attached with bolts and steel strap to the east concrete wing wall adjacent to and immediately upstream of the spillway. A 13-foot steel ladder, bolted to the wing wall, allowed access to the spillway. A two-sectional staff gage was fastened to the wall, just upstream of the spillway.

Manning 4050A Sediment Sampler
For the sampler to be activated, the probe tips (attached to east wall and coupled to instrument by cable) had to be submerged by the rising stormflow. Closure of an electrical connection would cause the instrument to draw a water sample and deposit it into one of the twenty-four 450-milliliter bottles located within the instrument. The water samples were drawn through the collection nozzle attached to the top of the spillway (just as the sediment-laden water started to flow over the spillway it engulfed the intake nozzle at a pre-determined depth). The sample traversed through a plastic tube to the instrument and into a collection bottle. Samples were collected at timed intervals, usually hourly during onset of stormflow. Original sampling depth for the intake was 0.25 foot of flow, but was eventually was reduced to 0.15 feet. In the latter years of the project, most flows were less than 0.25 foot in depth.

Raingages, Recording
The District used Belfort Universal Raingages, which contain a weighing bucket to capture the precipitation (includes rain, snow, sleet, or hail). The weighed data is inscribed on a paper chart fastened to a cylinder geared to rotate around a clock mechanism. Capacity of the bucket and chart is 12 inches. The smallest measurable unit is 0.01 inch. This recording raingage is usable under all weather conditions and is more accurate than the tipping bucket raingage.

Single-stage sediment sampler
Consisted of one 450-milliliter glass 'milk' bottle, large rubber stopper and two copper tubes specifically curved to form upstream intakes, set one above the other. The bottle and tubing were secured in a metal holder frame attached to a post or plank at the edge of the channel. As stormflow increased, sediment-laden water entered the lower intake and rose up to the crescent curvature of the lower copper tube. The solution then filled the bottle to a pre-set height, or until one of two things happened. As flow continued to rise, air exiting the upper intake tube was blocked and deposition into the bottle ceased, or if stormflow started to recede before bottle had filled, deposition ceased as flow dropped below the curved neck of the intake tube.

Suspended Sediment Sampling Techniques

Samples were individually collected, capped, and labeled on site, and transported to the Office laboratory. Samples were collected by one of three different pieces of equipment, dependent upon the site, a single-stage sampling bottle, a Manning Sediment Sampler, and a DH-48 Sampler. [The DH-48 was a portable hand-held sampler with three parts: intake nozzle, cast-aluminum case, and a three-foot wand. A 450-milliliter glass 'milk' bottle was inserted into the casing at an oblique angle, and held in place by a short, spring-loaded rotating arm. While wading in the stream, the instrument was lowered into the stormflow with the nozzle pointing upstream. The sampler was slowly raised and lowered until the bottle was nearly filled. The bottle was then removed, capped and labeled.] At the Lab, the sample bottles were cleaned (to remove exterior materials adhering to glass or plastic surfaces), weighed and measured, and the data was recorded. The samples were then stored to allow the contents to settle. Eventually, the water was carefully decanted and the sediment contents deposited into individual drying cups. Bottles were washed and allowed to air-dry. The weights of all containers, with caps, were measured and recorded and each sample was placed into a drying oven for 24 to 48 hours. When removed, the samples were weighed again and the data recorded. The data was then computed and used for yearly reports

Suspended Sediment

The volume and velocity of the stormflow, the availability of sand, silt, and clay particles for suspension in the watery solution, and the turbulent mixing that occurs during stormflow determines the quantity of sediment that is carried at any particular period of time. The sediment is computed in parts per million for each sample. The daily average of each day's data is inserted into a formula with daily flow data, average sediment weight, and several constant factors. The end product is in tons and acre-feet per day, which is then summed by month and year.

Bedload Sediments

There was no attempt to measure bedload sediment during the length of this project. The measurement of bedload was not anticipated when the project was first initiated, because the heavier materials were being deposited in the Barrier Dam reservoir, while the materials remaining in suspension were measured as they passed over the spillway. Only during the last five years of this study did the bedload question become relevant. Since the two stations upstream were measuring suspended sediments, the measurements at the Barrier Dam continued as before to remain consistent for comparison between sites.

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STREAMFLOW DATA SUMMARY AT BARRIER DAM BY CALENDAR YEAR, JANUARY TO DECEMBER

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	AVG/TOTAL
	AVG. CFS	17.6	19.1	8.8	0	0	0	14.9	35.9	58.1	548.2	7.2	8.7	59.9
1983	TOTAL AF	34.9	340.8	52.1	0	0	0	118.5	570.8	1149.0	9786.0	42.9	17.3	12112.3
	PEAK FLOW					10/2 2.85 FEET 5147 CFS								
	AVG. CFS	8.9	0	0	0	17.6	35.2	57.5	23.4	14.7	19.1	0	18.1	16.2
1984	TOTAL AF	58.2	0	0	0	34.9	418.7	1368	742.8	146.3	111.0	0	215	3094.9
	PEAK FLOW					7/19 0.92 FEET 902 CFS								
	AVG. CFS	2.7	0	8.7	5.2	0	0	53.7	18.7	66.2	62.9	0	0	18.2
1985	TOTAL AF	27.2	0	17.2	30.9	0	0	638.4	333.5	1576	1997.7	0	0	4620.9
	PEAK FLOW					10/16 1.15 FEET 1278 CFS								
	AVG. CFS	0	16.8	7.2	0	0	27.0	25.5	32.0	15.4	8.5	51.3	6.9	15.9
1986	TOTAL AF	0	100.0	28.5	0	0	160.5	404.8	1015.7	122.2	84.2	508.6	68	2492.5
	PEAK FLOW					7/4 0.57 FEET 421.6 CFS								
	AVG. CFS	0	20.2	0	0	5	17.6	12.2	7.8	15.1	3.1	13.8	9.8	8.7
1987	TOTAL AF	0	40.1	0	0	19.5	34.9	24.2	201.9	59.9	6.1	81.9	174.9	643.4
	AVG. CFS	0	11.5	0	0	0	0.3	14.3	61.0	37.0	22.0	0	0	12.2
	PEAK FLOW					9/3 0.60 FEET 458 CFS								
	AVG. CFS	2.1	0	0	0	0	0	19.4	7.1	1.2	101.1	0	0	10.9
	PEAK FLOW					10/2 0.74 FEET 640 CFS								
1990	TOTAL AF	0	0	0	0	0	0	404.8	449.4	142.2	115.4	160.8	285.3	1557.9
	PEAK FLOW					8/1 0.48 FEET 318.9 CFS								
	AVG. CFS	0	6.7	5.7	0	0	0	13.1	28.1	14.7	0	0	72.9	11.8
1991	TOTAL AF	0	13.3	11.3	0	0	0	52.2	439.7	116.5	0	0	1591	2224.0
	PEAK FLOW					8/26 0.33 FEET 170.6 CFS								
	AVG. CFS	0	15.3	14.5	9.6	7.6	0.3	27.1	22.6	17.6	0	0	2.9	9.8
1992	TOTAL AF	0	60.8	57.4	95.5	135.3	0.6	107.7	314.1	34.9	0	0	46.6	852.9
	PEAK FLOW					12/21 1.05 FEET 1110 CFS								
	AVG. CFS	32.3	0.5	0	0	0	0	11.3	38.7	8.7	17.6	20.2	0	10.8
1993	TOTAL AF	898.3	1	0	0	0	0	67.6	691.1	51.5	69.8	40.1	0	1819.4
	PEAK FLOW					8/31 0.90 FEET 872 CFS								
	AVG. CFS	0	0	3.1	0	0	20.2	7.9	16.5	15.6	0	28.3	18.7	9.2
1994	TOTAL AF	0	0	6.1	0	0	40.1	62.4	229.6	216.1	0	169.4	222.3	946.0
	PEAK FLOW					9/3 0.24 FEET 97.7 CFS								
	AVG. CFS	11.8	9.6	0	0	0	0	0	2.4	5.5	0	0	0	2.4
1995	TOTAL AF	234.6	95.1	0	0	0	0	0	23.3	43.9	0	0	0	396.9
	PEAK FLOW					2/22 0.22 FEET 83.4 CFS								

Chronology of Events on San Simon Watershed

1850's-1860's	Settlement in southern half of San Simon valley, spreading north to Gila River
1859	Establishment of Butterfield Stage Coach station at San Simon
1883	Drainage ditch dug at mouth of San Simon River to drain excess flood waters. Freight wagon road already established up the valley
1895	Estimated 50,000 head of cattle grazing in valley
1902-1905	Extended drought followed by heavy flooding in 1905 and 1906, start of channelization
1914-1915	Extended drought followed by heavy flooding in 1916, estimated 60 miles of river bottom channelized
1930's	CCC builds erosion control structures
1940's	SCS builds Lower Cienega, Halfway and Goat Well Detention dams in 1940 and Upper Cienega Dam in 1947
1950	DOI issues report estimating San Simon Watershed furnishes 2.6% of water to San Carlos Reservoir and 29% of sediment
1953	BLM builds Fan Drop Dam
1956	Creighton and H-X Dams
1956-1958	Geological Survey estimates amount of sediment leaving watershed
1957	Stop Work Order issued by Secretary of Interior
1965	Stop Work Order lifted
1966	West Well and Olga Dams
1967	Ryan Dam
1968	Ryan Dike and Whitlock Dam
1969	West Doubtful Dam
1970	Cove and 111 Dams
1972	Sands Draw Dam
1980	Barrier Detention Dam constructed Tanque Recording Raingage installed late in year

1981	Slick Rock Detention Dam constructed
1982	South Well Detention Dam constructed Elma Mine Recording Raingage installed mid-year Howard Well Recording Raingage installed late in year
1983	Creosote Detention Dam constructed Streamgaging station and automatic sediment sampler installed at Barrier Dam in January Ash Peak Recording Raingage installed mid-year Five permanent crosschannel survey transect lines established above Barrier Dam mid-year Single-stage sediment samplers installed at Bailey Well and Fan Dam in September September-October 'El Nino' flood
1984	Additional bottles added to single-stage sediment samplers in February
1987	Elma Mine Recording Raingage vandalized mid-year
1989	Van Gausig Recording Raingage installed early in year Five crosschannel transect lines above Barrier Dam re-surveyed mid-year Howard Well Recording Raingage vandalized late in year Permanent crosschannel survey transect lines established at Bailey Well and above and below Yellowhammer Well late in year
1990	Fan Dam survey transect lines relocated and re-surveyed mid-year Streamgaging stations installed at Fan Dam and Yellowhammer Well mid-year
1992	Crosschannel transect lines re-surveyed at Bailey Well and above and below Yellowhammer Well early in year
1993	Area-wide flood in January; One hundred cfs peak flow from San Simon River. Ash Peak Recording Raingage removed mid-year
1995	Five crosschannel transect lines above Barrier Dam re-surveyed mid-year Crosschannel transect lines re-surveyed at Bailey Well and above and below Yellowhammer Well mid-year Ceased sediment monitoring operation end of December Streamflow monitoring to be continued for several years

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